JULY 10, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY

OF MICHIGAN
JUL 17 1961
ENGINEERING LIBRARY

SNAP Generator Fastened to Transit IV-A

New Era Dawns for Nuclear Space APU's .

Laser Seen Replacing Radar Navigation .

A Satellite Test of Einstein Theory? 32

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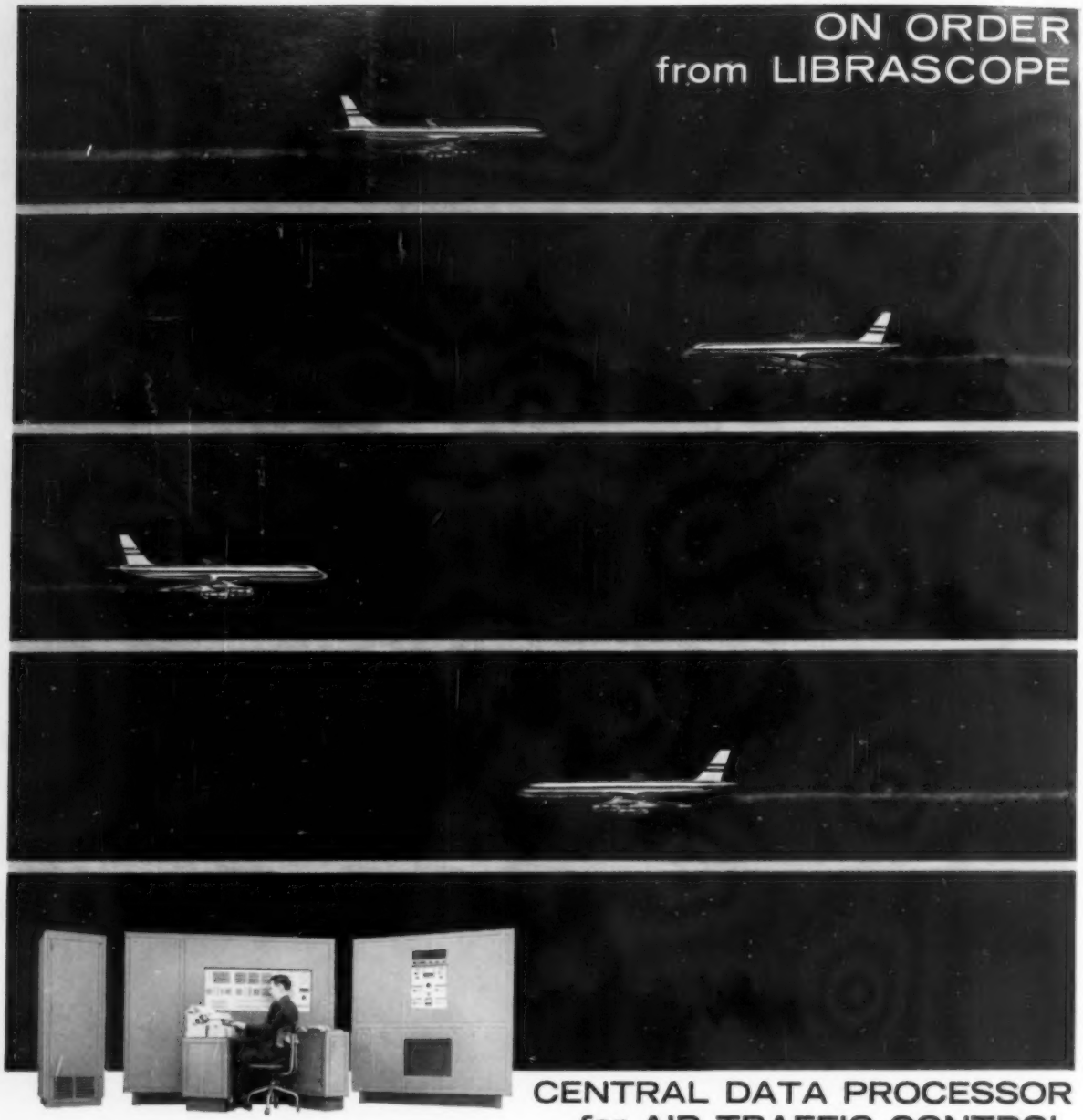

CENTRAL DATA PROCESSOR for AIR TRAFFIC CONTROL

Today, at a peak traffic hour, approximately 200 aircraft flew over the New York area. Each year this number will increase. Yet, the Federal Aviation Agency will continue to assure safe and efficient control of air traffic. One reason . . . a data processor developed for the FAA by Librascope to quickly and accurately handle the routine clerical tasks now occupying most of the controller's time. The first 18-unit data processor will be installed at Boston in 1962. A note to Librascope outlining your control problems will bring a prompt answer from the country's most versatile manufacturer of computer control systems.

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Is Defense Advertising Necessary?

There has been a lot of talk lately about the cost of the advertising done by defense contractors. One prominent Senator recently said he was greatly disturbed over heavy defense advertising expenditures. He pegged the cost "to the taxpayer" at $500 million.

This figure is many, many times the actual total of defense advertising expenditures and only a fraction of that total is recoverable. The Senator's facts are wrong; but, even more disturbing, it appears that he doesn't understand the purpose and function of sound advertising. He considers this money down the drain and thinks it should not have been spent.

There are other instances demonstrating a growing wave of anti-advertising sentiment in high government places. They indicate a lack of understanding and represent a threat both to freedom of the press and success of the Nation's defense goals.

We publish specialized business magazines and reference books. Several of these are defense oriented. They perform communications functions essential to our national goals . . . more essential now than ever before because of the complexity of today's technological and political challenges. There are other excellent magazines having the same or similar purposes. We're delighted—because competition is healthy and because there is more to be done than can be handled by any one of us.

Virtually all publications are financed, by and large, by advertising. This is healthy, too; but it is not the primary reason for defense advertising.

We believe that advertising is an effective and necessary tool for the defense contractor. The objectives of defense advertising are many: some of them obvious, others more subtle.

Sales is one obvious objective. It can be demonstrated that advertising, for some defense products, has led directly to sales. In other instances, selling is a long, complex process, where features of current products may not be as important as company reputation. In both cases, the government wants competition for defense contracts—by use of a competitive bidding system, it gets better products for less money. How is a company to compete if it is not allowed the use of sales tools—one of which is advertising?

Recruiting is another obvious objective. Will that engineer who is inspired to contribute to technological advancement in the missile/space age, for example, be interested in learning more about the kind of company he goes to work for? You bet he will, and more power to him.

The dissemination of technical information is a third, and perhaps the most important, objective. The exchange of such information is one of the biggest problems facing both government and industry. And what more effective, more economical means of disseminating necessary technical information exists than the business press? Mills Shepard, who performs readership studies on one of our publications, reports that advertisements are often read as avidly as the editorial pages. And Eastman Research, in a study released May 29, based on more than 100 surveys for 32 business-paper clients over a two-year period, reports that *70% of the readers interviewed read the advertising in these businesspapers on purpose.*

There are many other equally important objectives. Companies must raise capital in order to be able to do the jobs that need doing for defense. Good community and employee relations are considered necessary to a company's well-being. These and other objectives have been effectively achieved by defense contractors through advertising.

The defense industry is made up of numerous private companies facing the tremendous challenge of meeting, in cooperation with the government, our national technological goals. To meet this challenge, the companies must be strong and healthy. To deprive them of the use of effective and honest advertising is shortsighted and wrong.

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How the ocean grew "ears" to pinpoint missile shots

A quarter of the world away from its launching pad an experimental missile nose cone splashes into the ocean.

How close has it come to the target?

Where can it be found, recovered and studied?

To answer these questions quickly and accurately, Bell Telephone scientists have developed a special system of deep-sea hydrophones—sensitive "ears" that hear underwater. Its name—the Missile Impact Locating System, or MILS for short. MILS, produced by Western Electric, manufacturing and supply unit of the Bell System, involves two types of networks.

- One is a Long Distance network which monitors millions of square miles of ocean. The nose cone releases a small bomb which sinks and explodes at optimum depth for transmission of underwater sounds. Vibrations are picked up by hydrophones stationed at optimum depth and instantly carried by cables to ground stations. Since the vibrations take longer to reach some hydrophones than others, time differences are measured to compute the location of the nose cone.
- The other is a "bull's-eye" network which monitors a restricted target area. This network is so sensitive that no bomb is needed. It can detect the mere splash of an arriving nose cone and precisely fix its location.

MILS is now operating in both the Atlantic and the Pacific test ranges. It was installed by the U. S. Navy with technical assistance from Western Electric.

It's still another example of how the universe of sound—below the sea, above the earth, in outer space—is constantly being explored by the Bell Telephone System.

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 9, Number 2 July 10, 1961

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THE COVER

Tiny SNAP generator is fastened to base of Transit IV-A satellite prior to launching June 29. Nuclear powerplant was built by Martin under AEC contract. See p. 12.

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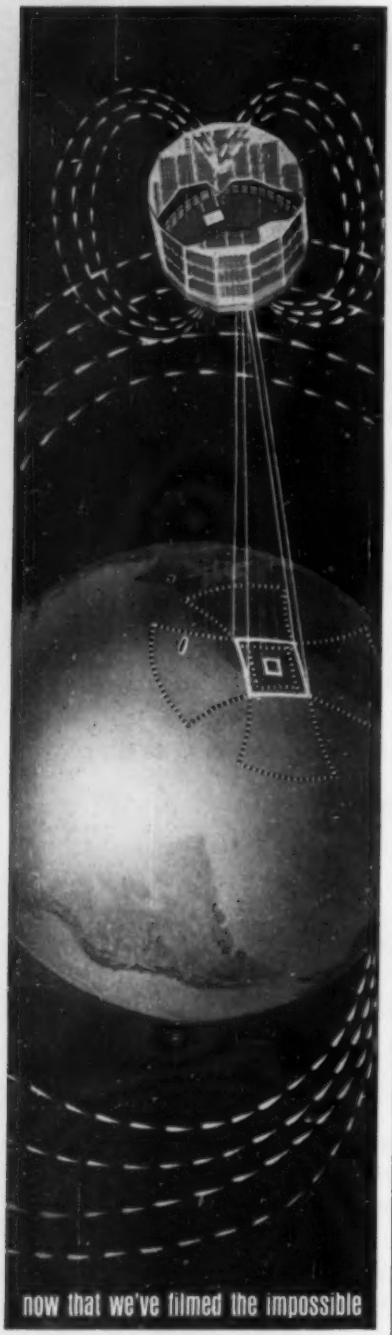

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letters

Emphasizing Quality

To the Editor:

I have just read your editorial, "A New Emphasis on Quality," in M/R, June 26. It is gratifying to know that a respected magazine is expressing concern over the procurement problems which beset defense spending.

As you know, I have been involved in defense procurement since the beginning of World War II; and I am thoroughly convinced that in order to practice economy, it is essential for us to consider total cost over the entire useful life of our weapons systems.

I appreciate the fact that you included some of my remarks in your editorial.

W. A. MacDonald
Chairman of the Board
Hazeltine Corp.
Little Neck, L.I., N.Y.

To the Editor:

I want to compliment you on your editorial, "A New Emphasis on Quality." It was excellent.

H. Thomas Hallowell, Jr.
President
Standard Pressed Steel Co.
Jenkintown, Pa.

To the Editor:

I liked your editorial, and wish to offer a vote of applause from the standpoint of an operator of military equipment.

As missiles, aircraft, ships, weapons and electronics have increased in complexity, the reliability curve has dropped. The answers have included "jury rig" solutions such as providing not only the hardware but a bevy of scientists to go along with the equipment and baby it along (and at great expense). This can never be the way to fight under actual combat conditions.

Another consequence of deteriorating reliability has been the frantic efforts by the military to increase the educational level of officers. This, while helpful, can never be a panacea.

Industry, DOD and the operators should be of a single philosophy, namely that hardware must be 100% reliable, or it is of no value militarily. Defining what 100% reliability amounts to would be a challenging task, however (considering conditions which exist during actual conflict), this philosophy should stand up.

Another factor bearing on the subject is that the military "operators" are average Americans—not geniuses. This will be so as long as the economic climate of the country remains so prosperous. Most very-high-level engineers are lured by the opportunities represented by the multi-page want ads in papers like the *New York Times*—under the heading "Engineers." Equipment, therefore, must conform to the capabilities of the operator on an instantaneous response basis . . .

Capt. J. E. Hart, USN
Monterey, Calif.

Life Support at AMF

To the Editor:

Your article entitled "Life Scientists Demand Top Priority" (M/R, May 29, p. 44) in the special issue on Man-in-Space was read with great interest by our staff.

While we certainly agree that there is a need for more emphasis on the development of advance life-support systems, the picture is not as black as depicted in your article. As was shown at the 32nd annual meeting of the Aerospace Medical Association in Chicago this spring, several companies including American Machine & Foundry have developed the technology necessary to build advanced life-support systems.

We do not agree that (1) "insufficient emphasis has so far been placed on the requirements of human occupancy for long-duration voyages," (2) "a satisfactory approach to development of life-support equipment has not been taken . . ." or (3) "the lead times for life-support systems are much longer than for other systems and the present lack of effort is really going to hurt."

The Air Force and NASA are sponsoring work to obtain flight prototype systems for gas conditioning, oxygen regeneration and water recovery. When an actual requirement exists for a specific vehicle, qualified systems can be developed in less than two years. A very good approach has been adopted for developing these systems, namely, environmental simulators as used by the School of Aviation Medicine, Aerospace Medical Division of ASD, and the U.S. Navy Air Crew Equipment Laboratory.

During the past year we have assembled an automated experimental model of an integrated life-support system capable of servicing three men on extended missions. All the analysis and laboratory test necessary to verify the feasibility of this system has been performed. We are now concerned with improving the maintainability of this system, which contains a catalytic burner, regenerable CO_2 and odor removal station, reactor for reducing CO_2 with hydrogen, electrolysis unit for generating oxygen, and a compression distillation water recovery component. This approach imposes the least mass and power penalty of any "closed" water-oxygen system known today, and should satisfy all manned space-flight environmental requirements for the next 10 to 20 years . . .

R. A. Bambanek
J. D. Zeff
American Machine & Foundry Co.
Niles, Ill.

The remarks quoted in the third paragraph of the above letter were made not by M/R but by industry experts. The less-than-two-years' lead time required, according to Messers, Bambanek and Zeff, for development of qualified life-support systems for "actual requirements" seems to us to be a substantial length of time and

to underline the urgency of acquiring better knowledge of radiation and weightlessness as soon as possible.—Ed.

Saturn by Dirigible

To the Editor:

An article in the June 12 M/R (p. 16) reports that the collapse of one of the locks on the Tennessee River will probably delay the September firing of the *Saturn*, as this blocks the transportation of the *Saturn* via barge from Huntsville to the Cape, and that officials are frantically searching for other means of transportation.

Last November an all-metal, stressed-skin airship was proposed to NASA and the Army Transportation Corps. The ship, designated the SMD-100, has been brought to NASA's attention numerous times in the past eight months, but with the same reaction each time, as per the enclosed letter signed by Maj. Gen. Don R. Ostrander, the consensus being (prohibitive) cost. May I suggest that, where we are dealing with the 17,000-mph missile and are pushing it around in a barge at 3-knots-per-hour, it is vaguely reminiscent of the first aircraft purchased by the Army—which had to be designed so that it could be carried on a standard Army wagon.

This means of moving missiles or launching pads or any other heavy equipment that would be impossible to move by any other known surface method was not offered for sale to the government or any other agency. This offer was made to move any of the above-named items strictly on a weight-mileage basis or a contract to move any time, any place, either full- or part-time. We have had a number of inquiries from commercial firms, some in foreign countries, in regard to using this equipment to move perishables and various other things. This equipment would be built and owned by private enterprise, will be classed as a common carrier such as any steamship or any freight carrier or other methods of transportation. Actually, to move the entire *Saturn* unit from Los Angeles to Florida and back, which is your portal-to-portal on equipment of this order, would be roughly $50,000 and would be completed within 24 hours.

So you see that the General's letter quoting total costs is not exactly true because the development and operation of this unit doesn't enter into any part of any contract. During the war, the government leased large passenger ships for troopships from the various steamship companies, and this would operate on the same principle for the exclusive use of this ship for a three-year period. It could be used not only for missile deliveries, but for any other heavy equipment to be moved anywhere in the world. In closing, I would like to ask a question: If, with the present equipment, we can't move the *Saturn*, how are we going to move the *Nova?*

C. W. Farrar
Executive Director
Associated Specialists Inc.
Los Angeles

Editor's Note: Gen Ostrander's letter stated that use of dirigibles to transport Saturn stages cannot compete economically with water transportation, due primarily to the fact that initial Saturn stage production rates are too low to utilize the total transportation capacity of such a vehicle. Gen. Ostrander estimated total costs, both developmental and operational, for the proposed dirigible, amortized over 5 years, at five times those of water transport. Associated Specialists Inc. estimates cost of the first dirigible at $15 million, second at $8 million, and others at $6 million each.

Ivy and Missilery

To the Editor:

Congratulations on "New Route to Cathay" (M/R, May 29, p. 37). Mr. Cooper's well written simile to our man-in-space program is both amusing and disturbing. The astonishing lack of understanding of the urgency for a sound and practical space program seemed as far beyond the capacity of the Eisenhower Administration as the need for large rocket engines and ballistic missiles was to Truman's. What President Kennedy's position will be is not yet clear in my mind.

Since the launching of the first Soviet satellite vehicle, one factor has become increasingly clear. High-level scientific advisers to the Administration and government agencies have, in a large part, been drawn from university teaching and administrative staffs. These people have subsequently been dubbed by the public relations men "missile experts" or "space experts." Like many others who were associated with the missile/space effort in the years prior to *Sputnik I*, I have searched my memory and files for any evidence of work performed by these people in the areas in which they are now assumed to be experts. I find none.

There is, however, increasing evidence that these people are bringing with them from the campus every pet academic project for which they could not acquire support at their university research institute.

To date, what success we have enjoyed in our missile and space programs has been the result of good engineering practice making use of existing scientific knowledge. For what we could have done, those in government have only to dust off old proposals submitted in the years when there was "no requirement for large rocket engines" (1947-1953). Now we have a different situation. Our former teachers are leaving the hallowed halls and want to research any and everything to death. Left to these people, we might still be "optimizing the plowshare." Time after time we hear the cry, "the Soviets are doing it, so must we."

Just a few weeks ago I had occasion to speak with the director of a large university research activity who has had considerable contact with Russian scientists in his field of work. He mentioned that they use the same technique to gain government support for their pet projects.

The needle that prompted this letter was your article, "Life Scientists Demand Top Priority," just a few pages behind Mr. Cooper's. This program sounds very much like the beginning of one of the bigger and better boondoggles which have come to light in recent years. Let's keep professors in universities, working scientists in the laboratories doing basic research, and leave the hardware development to engineers.

How you replace university presidents whose recent experience is fund-raising for a new library with people from industry who know and have worked with our technical problems for years is beyond me. Perhaps the government public relations people find that they don't have the proper public "image."

J. S. Tillman
Sunnyvale, Calif.

'Incredible' Misspelling?

To the Editor:

In M/R, April 3, p. 36, there is a paragraph:

"The program includes an observation of Venus by *astronomer* A. Dollf*uss* from a high-altitude (80,000 ft.) point where he will be taken by a 'grape' of 30 balloons."

Dr. Audouin Dollfus is an astrophysicist, not an astronomer, and the name is spelled with one, not two, s's. I realize that most of these errors occurred in *Shell Aviation News* of November, 1959, which shows photographs of the apparatus and of Dr. Dollfus and his father, Charles.

It would seem to be inexcusable in the Shell organization to have the name misspelled. To mispell it in a semi-scientific publication is incredible. If the item as indicated came from Paris—there it is completely incredible, where everyone knows the family and they can be checked in the local directories. Although now retired, Charles Dollfus is editor of "Histoire de L'Aéronautique" (as well as the companion volumes of histories of railroads, steamships, automobiles).

The surname might, of course, have been changed to the German form with two s's, but this seems to me unlikely. When Dr. Dollfus was here in the USA for nearly a year recently on astrophysics exchange work, I never saw his name incorrectly spelled by the *New York Times* or any of the publications of the American Institute of Physics. I cannot remember its ever being wrong in Science Abstracts-Physics.

Pearl I. Young
Lancaster, Pa.

Suggested Reading

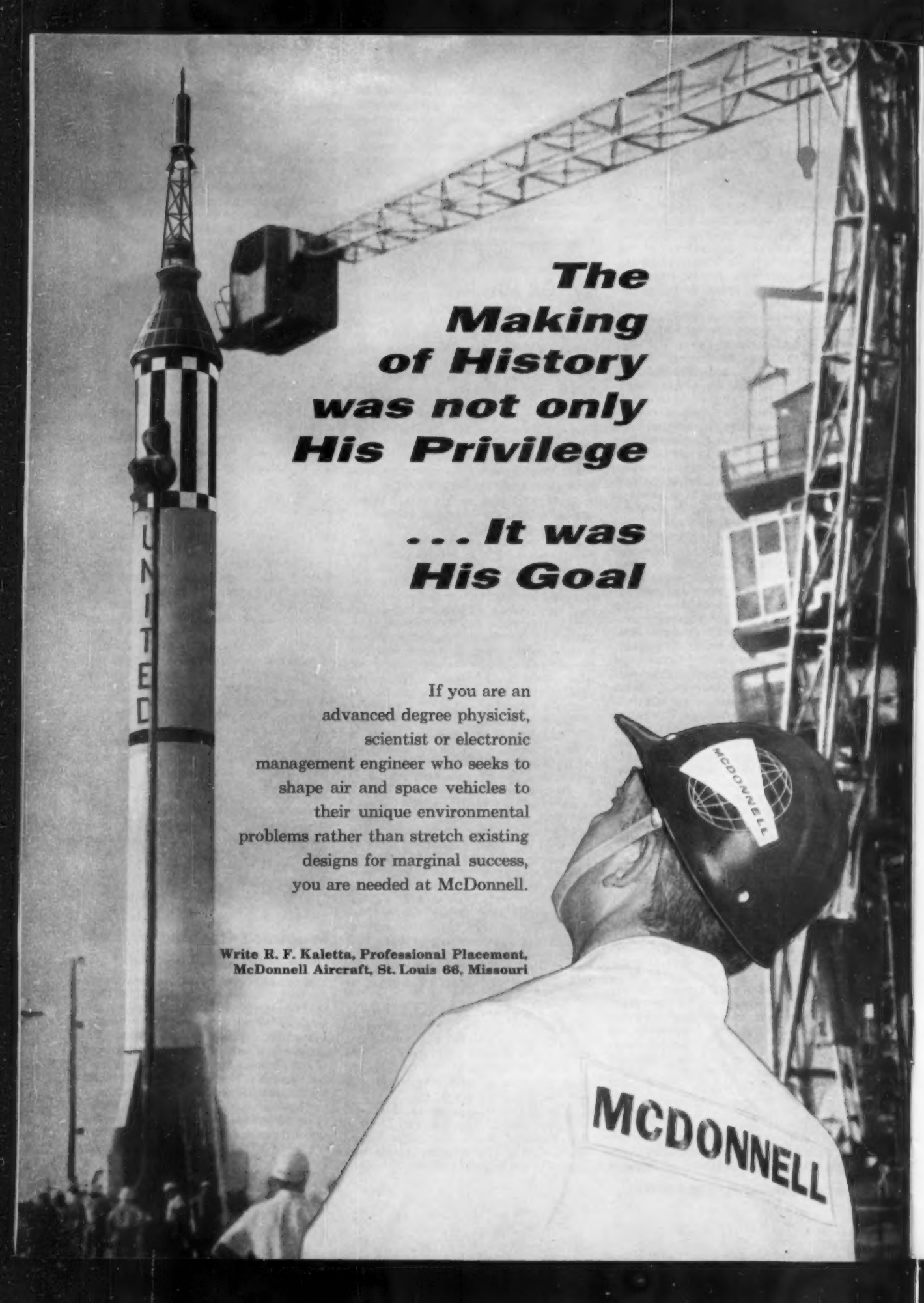
To the Editor:

I would like to recommend to everyone the book "America: Too Young to Die," by Maj. Alexander P. de Seversky (McGraw-Hill Book Co., Inc.). This book is a shocking criticism of our defense program, and it calls for a vast reorganization of our defenses to avoid destruction.

There is a 16-page condensation of the book in the July issue of *True* magazine.

Again I urge you to revive M/R's "Countdown for Survival" to help prevent our destruction.

David W. Johnston
Washington, D.C.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The Countdown

WASHINGTON

ICBM's—Where Do We Stand?

Searching closed-door hearings into U.S. strategic missile capability will be conducted this month by the Senate Preparedness Investigating Subcommittee. Major questions concern the availability, reliability and operational readiness of *Atlas, Titan, Minuteman* and *Polaris* along with *Skybolt* and *Hound Dog* and the "mix" of these missiles with bombers. The subcommittee also wants to know why Defense Secretary McNamara is stopping at the 29th *Polaris* submarine.

ComSat—Decision in Making

President Kennedy's National Aeronautics and Space Council is meeting this week to come up with recommendations on the communications satellite program. Betting now is that it will favor NASA R&D participation in a commercial satellite through Project *Relay*. But how the ownership question will come out is still up in the air. The FCC, incidentally, vacations in August. If an Administration decision isn't forthcoming on how many and what companies should own the venture, the FCC may not be able to act until September.

Non-Profit Inquiry Starting

The House Space Committee is taking its inquiry into DOD's non-profit "think" corporations off the backburner and will hold hearings late this month. Reason: congressional ire stirred up by reports of high salaries and unnecessary expenses run up by the corporations. Insiders are saying, however, that the investigators will find the headline pickings pretty slim—preliminary findings have unearthed practically nothing of a sensational nature.

Lunar Exploration Reshuffle

There are indications that NASA is considering a major overhaul of its *Ranger, Surveyor* and *Prospector* programs to speed them up. Several companies are offering proposals for modified lunar soft-landing packages. They are designed to get information about lunar conditions quicker, so that the data can be pumped into the *Apollo* program.

On the Pad

Following up the shot this month will be a third *Mercury Redstone* manned suborbital flight in August. Also next month, another try at orbiting an unmanned *Mercury* capsule aboard an *Atlas*. It will be followed in September—if successful—with an attempt to orbit a primate. Other NASA shots: a *P-32 Ranger* lunar payload with an *Atlas-Agena* about July 28; an *S-3* energetic particle satellite and an *S-55* micrometeorite satellite in August.

INDUSTRY

Astropower A-building

Douglas Aircraft's Astropower Inc. subsidiary is occupying an 85-acre site south of Los Angeles under a lease-option agreement. Testing is expected to begin in August at a test site built by the owners. Astropower is to get occupancy next May of new 40,000-sq.-ft. building.

←——Circle No. 3 on Subscriber Service Card

NASA's Patents—No Change

Although the House Space Committee may vote out a bill to bring NASA's patent policy in line with DOD's, the legislation isn't expected to pass Congress. Senate Space Committee, it's reported, will go along with NASA Administrator Webb's stand that no changes are needed at this time.

Kiwi-B on the Move

Rover nuclear rocket program's *Kiwi-B* reactor is being taken piecemeal from Los Alamos and reassembled at the AEC's Nevada Test Site. First hot run of the highly automated test unit is due in October.

R&D Intelligence

Using Curium 242, some nuclear physicists now feel, can upgrade the output of a *SNAP* unit to 30-40 watts. . . . NASA is being attacked on its request for $60 million to build a new space flight lab. One congressman says it's an open invitation to "raid" other biomed agencies. . . . Solid-propellant men are contending that the biggest obstacle to constructing megapound-thrust solid boosters will be in developing the proper motor cases. . . . Newly de-mothballed and outfitted ($30 million) American Mariner ship for Project DAMP (Downrange Antimissile Measurement Program) is now on her shakedown cruise.

Autonetics Shifts 5000

North American's Autonetics Division has wound up the transfer of its Computer and Data Systems from Downey to East Anaheim, Calif. Relocation involved 5000 personnel.

INTERNATIONAL

European "Space Club" Set

West Germany has agreed in principle to participating in a European cooperative satellite launching program costing some $200 million over the next five years. This removes the last apparent obstacle to formation of the "Space Club," which hopes to orbit satellites up to one-ton with a three-stage vehicle based on the British *Blue Streak* IRBM. Britain's share of the cost is to be one-third. Participating nations are expected to lean heavily on U.S. missile/space industry know-how to get the program rolling.

Overseas Pipeline

Launch of Israel's first sounding rocket—the *Shavit II*—is believed to have been from a site at Mt. Carmel. . . . Labor problems are still dogging construction of the British BMEWS station on Fylingdales Moor. . . . There's word that Britain is leaning toward purchase of Nord's *AS-30* air-to-surface missile.

Wary Eye on Woomera

Red Chinese nuclear technicians are reported staffing their Djakarta, Indonesia, embassy—apparently to keep a wary eye on British Vulcan bombers conducting drop tests with the *Blue Steel* stand-off missile in the Woomera Missile Range.

The Missile/Space Week

Israel's Rocketry Debut

Israel became the seventh country to study the weather with rockets when it successfully launched *Shavit Shtayem (Meteor II)* 50 miles into the ionosphere.

The multi-stage, solid-fuel rocket exploded a cloud of sodium at its maximum height to permit observation of prevailing wind conditions. No telemetering equipment was carried, official sources said.

Launching place was secret, as was the exact number of stages comprising the rocket. Total weight was given as from 550 to 660 lbs.

Other countries with meteorological rockets: United States, Soviet Union, France, Great Britain, Italy and Japan.

Shots of the Week:

An attempt to gain more data on the micrometeoroid picture failed June 30 when the third stage of a NASA *Scout* vehicle exploded in flight.

The vehicle, which reached an altitude of about 70 miles, carried a 187-lb. satellite instrumented to measure the micrometeoroid hazard in space. It was launched from Wallops Island.

The Navy's *Transit IV-A* was still working perfectly after a three-in-one satellite launch from Cape Canaveral June 29. The two other satellites, a 55-lb. *GREB* and a 40-lb. *Injun*, failed to separate and are in orbit together. (See p. 12.)

"Technical difficulties" caused the last-minute scrub of an Air Force *Midas* satellite launch July 2. The satellite was to have been launched at Point Arguello.

NASA to Launch for A.T.&T.

NASA will sign a contract before the end of this month to launch an experimental communications satellite developed and built by the American Telephone and Telegraph Company.

Under the agreement, NASA will provide the launching facilities, the launching rocket and network for tracking the satellite in orbit. A.T.&T. will reimburse the government for the cost of the launching.

The phone company will also be subject to supervision by the government and—as NASA officials put it—the experiment will be integrated into the government's program for development of a communications satellite system.

The A.T.&T. proposal is to build an "active repeater" satellite which would weigh about 130 lbs. and be placed in a 5000-mile orbit.

Nuclear Weather Man

The world's first atomic-powered automatic weather station soon will be shipped from The Martin Co. for operation in a remote location in the Canadian Arctic regions.

The unit, capable of transmitting temperature, wind speed and barometric pressure up to 1500 miles, derives its power from pellets of strontium-90. Heat is transformed into electricity by thermoelectric couples and stored in rechargeable batteries.

The elements and electronic components were produced by The Martin Co., and fueling was carried out by the Atomic Energy Commission's Oak Ridge National Laboratory in Tennessee.

L-T/CV Merger Okayed

Ling-Temco Electronics and Chance Vought stockholders have approved merger of the two companies into Ling-Temco-Vought, Inc. It will come into being Aug. 31 with assets of over $194 million and a $300 million backlog of orders. CV will be re-established as the aerospace subsidiary of LTV.

Robert McCulloch will be board chairman and chief executive officer, the position he now holds with L-T. The Justice Department meanwhile is looking into any possible antitrust violations in the merger.

Haymaker Heads NASA Lab

NASA has appointed Dr. Webb Haymaker Assistant Director for Life Sciences at the Ames Research Center, Moffett Field, Calif., and Di-

Plug Nozzle Mockup

GENERAL ELECTRIC is using this mockup for engineering studies on its plug-nozzle rocket engine propulsion concept. Nozzle would be used on 2.5-million-lb.-thrust engine. GE is now testing a 50,000-lb.-thrust plug-nozzle engine.

Radioplane's New Target Drone

LUNEBERG LENS LUGGING expendable RP-76 target aircraft is currently undergoing demonstration tests at Point Mugu for possible use as a fleet training target. The solid-propellant drone, developed by Radioplane, recently set an altitude record for unmanned aircraft—74,000 ft.

rector of the Life Sciences Laboratory.

The laboratory will conduct research in the three main divisions NASA has designated in the life sciences: space medical and behavioral sciences, space biology and biotechnology.

Dr. Haymaker is a neuropathologist, specialising in ultrasonic and ionizing radiation effects, decompression sickness, heat stroke, hypozemia (deficient oxygenation of the blood) and neuroanatomy.

Biggest High-Vacuum Chamber

Lockheed Missiles and Space Co. will begin testing space vehicles this fall in its $1.6-million high-vacuum orbital simulator just installed at Sunnyvale.

The stainless steel cylinder, largest known high-vacuum chamber, will be used primarily to test Lockheed's *Agena* spacecraft.

The 75 ton chamber is 20 ft. high and 18 ft. in diameter, with foot-thick walls. It will simulate altitude up to 200 miles and has a temperature range from −200°F to +320°F.

Johnson Nears Confirmation

Dr. Gerald W. Johnson, nuclear weapons testing expert, has been tentatively approved as chairman of the military liaison committee serving the Atomic Energy Commission.

Appointment of Johnson, who is associate director at Lawrence Radiation Laboratory, was approved by a Senate subcommittee. He has promised, if confirmed by the Senate, to cancel two private industry contracts he holds as a consultant.

Marshall Set to Expand

Marshall Space Flight Center's budget will double—to over $800 million annually—if Congress passes NASA's Fiscal 1962 budget requests.

Dr. Wernher von Braun, director of the facility, also told a "Space Day" banquet at Huntsville, Ala., that the center plans to hire 1000 more employes during the current fiscal year.

NAA Studies Rendezvous

North American Aviation's Space and Information Systems division is developing mathematical techniques to provide mechanics for satellite rendezvous under a new NASA contract.

Some of the aims of the program are to provide basic formulas for rendezvous, and to determine the best way to move a vehicle from one orbit to another with minimum use of fuel. The contract, for 15 months, is based on work North American did under a previous NASA contract.

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SNAP succeeds on Transit . . .

Era of Nuclear Space APU's Arrives

Fears of adverse reaction prove to be unfounded; way may be clear for flights of U.S. nuclear rocket engines

by Hal Gettings

MORE NUCLEAR power sources are to be flown in space soon—in both lunar and planetary probes as well as future *Transit* navigation satellites.

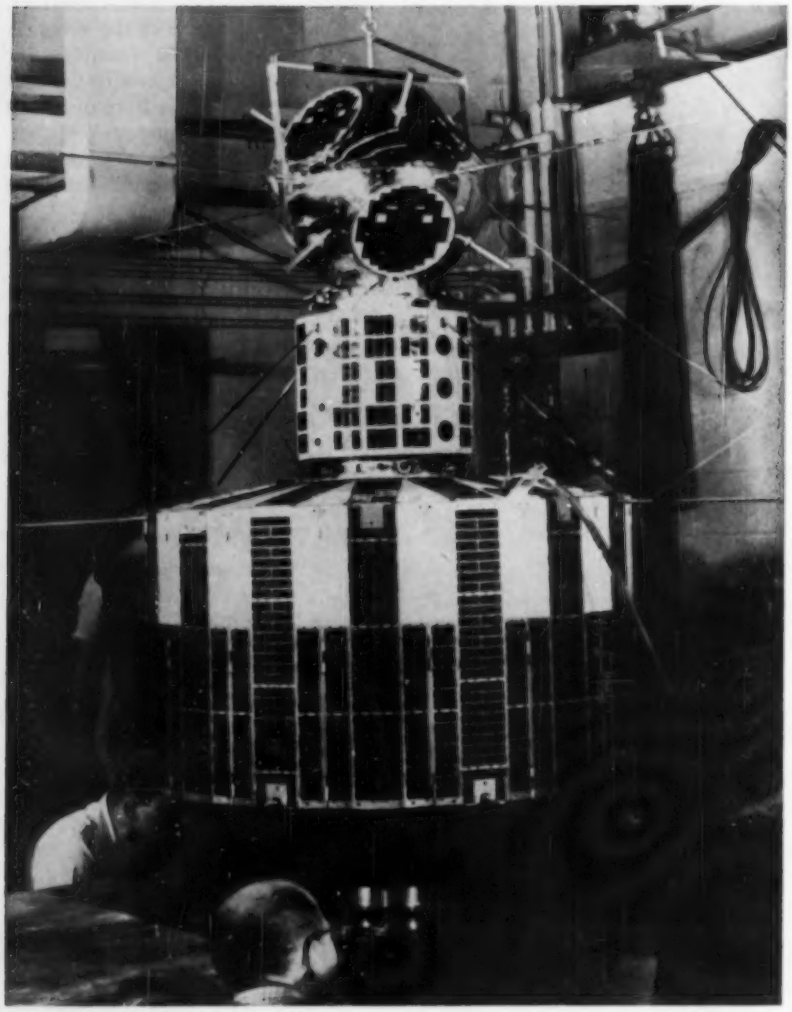
Some government officials are privately predicting, moreover, that the successful orbiting of a grapefruit-sized SNAP-3-type unit aboard *Transit IV-A* June 29 will ease the way for flight-testing of nuclear rocket engines.

Almost complete public indifference to the placing of the isotopic power source in orbit is being regarded in Washington as a political breakthrough of sorts. It also was ample evidence that official fears of international repercussions—fears that have delayed the flight of nuclear power devices for more than a year—were unwarranted.

Officially, the Atomic Energy Commission is denying there was a delay, claiming the time was used to make the unit 100% safe. But the State Department is known to have opposed the idea on grounds it might upset nuclear test ban negotiations with Russia and out of fear that an aborted launch might drop a radioactive source on foreign soil.

In any event, a new era of nuclear power sources in space appears to have dawned.

They are now expected to be designed into the *Surveyor* lunar soft landing vehicle, go aboard the *Mariner* spacecraft which will fly-by Venus, and be used in the operational *Transit* satellite. The Air Force may revive a plan to put them aboard *Discoverer*. (It had planned to use two 125-watt SNAP I-A units, but this unit was turned into a test bed.)



MATED SATELLITES were checked out prior to shipment in environmental test laboratory at Applied Physics Laboratory of Johns Hopkins University. GREB-III is sphere at top, Injun in center, and Transit at bottom of three-satellite stack.

• **Time reference**—*Transit* program officials said last week signals from *IV-A* were being received clearly at all their tracking stations. They said the distortion-free signals in an operational system in addition to providing highly accurate navigational reference could also provide an extremely accurate world-wide time service.

The only fault in the launch was the failure of two piggyback satellites, *GREB III* (to measure solar X-rays) and *Injun* (to measure radiation of the Van Allen belt), to separate. They were transmitting signals, but some of the instrumentation was unable to function properly.

All three satellites were in a 629/550 statute-mi. orbit with a 104-min. period.

The unnumbered SNAP generator used in *Transit* differs only slightly from the SNAP-3. Biggest difference is in the use of plutonium-238 as the heat-generating isotope rather than polonium-210.

Plutonium-238 is primarily an "alpha" emitter (the least penetrating of the three types of radiation) so that the generator requires no shielding at all; most of the energy of the alpha particles is used to produce heat within the device. Also, its relatively long half-life

(about 90 yrs.) offers maximum advantage over other types of power supplies.

The plutonium-238 isotope cannot support a chain reaction. Even in large masses, it presents no danger of atomic explosion.

The most hazardous aspect of plutonium is that all forms are poisonous if inhaled or ingested by living organisms. Consequently, the fuel of the SNAP generator must be enclosed in a manner which will prevent its accidental release. Martin Co., under AEC contract, undertook an exhaustive series of safety analyses and tests to demonstrate this design characteristic.

The SNAP unit in *Transit IV-A*, built by Martin Co., furnishes power for some of the satellite's instrumentation as well as that for two transmitters. The first signals from the satellite came from the nuclear-powered transmitters.

The unit is expected to last for five years or more. It weighs about one-fifth of an equivalent battery-solar cell system. In addition, it operates continuously, not depending on sunlight for energization.

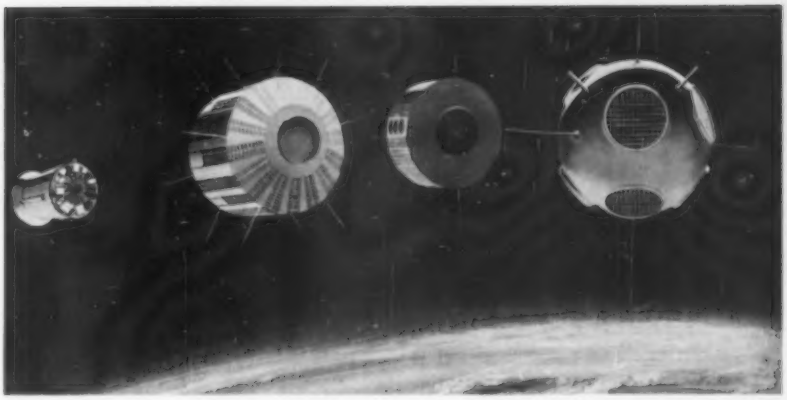
AEC will not name the thermoelectric material used to convert the nuclear heat directly to electricity. They say it is one of the most efficient developed to date.

Transit IV-A is the fourth in a series of satellites in the Navy's program to develop an all-weather, world-wide navigational system.

The satellite weighs 175 pounds. It is a polygon with a flat top and bottom and 16 sides. It is approximately 43 inches in diameter and 31 inches high. It has an improved memory system including an absolute time system which will periodically receive orbital data from a ground injection station. The satellite will transmit this orbital data continuously until new data is received from the ground to replace the old.

From a single passage of the satellite, a properly equipped station on the ground will be able to compute its own position from the orbital data and the shift in the apparent pitch of the satellite's signal due to the Doppler effect. The satellite is powered by solar cells and carries two nickel-cadmium batteries in addition to the SNAP generator.

The *Transit* system is being developed by the Applied Physics Laboratory of the Johns Hopkins University for the Bureau of Naval Weapons. The Forest Grove facility of APL at Silver Spring, Md., serves as the data injection station. The APL field station at Howard County is the primary tracking station. Other ground tracking stations are located at the University of Texas (Austin); the University of New Mexico (Las Cruces); and at various overseas locations. Naval Ordnance Test Station, China Lake, Calif.; Naval Weapons Laboratory, Dahlgren, Va.; Bureau of Ships; and the Pacific Missile Range are also participating in the *Transit* development program.



BOOSTED BY THOR-ABLESTAR, Transit IV-A carried two hitchhikers which failed to separate after going into orbit. Left to right: Ablestar upper stage, Transit, Injun and GREB. Satellites are not shown here in accurate proportion.

Transit has chalked up a record of four successes in six tries.

The first successful *Transit* satellite, *I-B*, went into orbit April 13, 1960. It was also the first satellite to demonstrate the technique of separating a pickaback vehicle into a separate orbit. It carried a metal disk which was separated from the satellite by the same type of device used with later piggyback satellites. *I-B* is now silent due to failure of a thermal switch.

Transit II-A was launched June 22, 1960. It is still transmitting signals, but only when the satellite is in sunlight; an exploded storage cell prevents it from storing energy to operate in the dark. *II-A* was the first satellite actually to carry a piggyback payload, the NRL GREB-I. Data obtained from *I-B* and *II-A* are being used in studies of the earth's size and shape and in other geodetic studies. They also are being analyzed to determine the effects of sunlight on drag.

Both *I-B* and *II-A* responded to command signals from the ground. Both also demonstrated the practicability of mechanical and magnetic de-spin devices which reduced satellite rotation in orbit.

Transit III-B was launched February 21, 1961, along with the NRL *Lofti*. Because of a malfunction in the launching vehicle, the satellites did not separate but orbited together with the second stage of the rocket. They re-entered the atmosphere and burned on March 30, 1961.

• **GREB-III**—Solar Radiation Satellite III *(GREB)* will provide a continuation of measurements begun in June, 1960, with the *GREB-I* satellite. Although externally similar, the latest *GREB* embodies modifications based on results obtained from the first satellite. Its 20-in.-diameter aluminum shell carries six 9-in. solar-cell patches. Electronic equipment is housed in a 12½-in.-diameter in the center of the 55-lb. sphere.

The purpose of the *GREB-III* is to measure the level of X-radiation from the sun. X-rays are emitted in greater quantities during solar storms, producing changes in the ionosphere which cause considerable disturbance to radio reception on earth.

Several improvements over the 1960 satellite experiment are incorporated in *GREB-III*. Since the ultra-violet radiation of the sun is relatively constant even during solar storms, the new experiment will monitor the sun with two X-ray detectors instead of with one X-ray and one ultraviolet detector.

• **INJUN**—The *Injun* satellite was designed and built by Dr. James Van Allen. Its purpose is to measure the intensity of cosmic radiation, especially in the inner and outer Van Allen belts, and to investigate auroral phenomena in both the Northern and Southern hemispheres.

Specifically, it is designed to make the following measurements:

—Detailed plotting of the auroral zones.

—Simultaneous plotting and monitoring of the Van Allen outer radiation zone.

—Monitoring of cosmic rays and solar protons over a wide range of magnetic latitudes.

—Measurement of charged particles trapped in both the inner and outer Van Allen belts.

—Measurement of particle downflux from the equator to auroral zones, together with simultaneous observations of airglow and auroral emissions, and subsequent correlation with phenomena measured at several ground stations in the U.S. and Canada.

—Study of both particle and light fluxes associated with the detailed structure of aurora. ¤

Short of Navy hopes . . .

NASA Plans Polar Orbits from PMR

by Hal Taylor

SEVERAL NASA satellites will be launched into north-south polar orbits starting next year—setting off a new surge of activity on the Pacific Missile Range.

Most of the launchings will be made from two *Thor* pads at Vandenberg AFB. But the space agency also is preparing to construct three *Atlas-Agena* and one *Scout* pad at the Navy's neighboring Point Arguello, Calif.

The *Atlas-Agena* pads—scheduled to be completed by 1963—will be used for tests of the missile by NASA and stepped-up firings in the Air Force's *Samos* and *Midas* programs. The *Scout* pad will be completed by mid-1962 and will be used by NASA for its ionosphere satellite testing plans.

NASA will kick off its Vandenberg program with an international cooperation shot with Canada. Using a *Thor-Agena B booster,* it will attempt to place in a north-south orbit a Topside Sounder *S-27* satellite, which will measure electron density in the upper atmosphere at altitudes from 200 to 700 miles.

Other shots in the NASA program include:

A rigid version of the passive communications satellite *Echo* to be launched in the last half of 1962.

The Orbiting Solar Observation satellite *S-16,* which will attempt to measure the sun's ultraviolet rays.

All of the shots in the *Nimbus* program. This is an advanced meteorological satellite weighing 650 lbs. and including six television cameras in its payload.

POGO—the Polar Orbiting Geophysical Observatory which will be launched with a *Thor-Agena B* booster.

• **Less than was hoped for**—While the stepped-up activity and construction will be a real boon to West Coast missile operations and fulfills both the Air Force's and NASA's plans for PMR, it is apparent that it falls far short of the Navy's hopes for its Point Arguello facility.

The Navy began construction of Point Arguello in 1957 in the belief that it was this country's last opportunity to build a missile range from the ground up which could provide the necessary facilities for years to come.

MAP SHOWS proposed new NASA launching facilities at Vandenberg AFB and adjoining Navy Pt. Arguello installation. (Broken line indicates boundary of Vandenberg.)

It originally advanced plans which envisaged the spending of some $4 billion on PMR facilities in a 15-year period. Included in the proposed launch sites were five pads for the Air Force's *Samos* and *Midas* programs, and pads for *Thor*-type vehicles.

NASA's decision to use Vandenberg's *Thor* pads for its polar-orbit satellite program kills chances for construction of *Thor* pads at Point Arguello. In addition, the Air Force was given control of the Defense Department's space program, which has curtailed Navy space plans.

As a result, no pads have been built at Point Arguello for strictly Navy use. However, what has hurt the Navy even more has been the decision to give a joint Air Force-NASA committee control over who will use launch sites and whether new ones should be built at both the Vandenberg and Point Arguello facilities.

At the same time, NASA and DOD objection have squashed Navy plans to spark further increases in Point Arguello activity as a launch site for the Air Force's proposed big solid booster engine, the construction of an equatorial launch site on a down-range island, and a mobile launch site on a ship.

Navy officials thought that the deep canyons at Point Arguello would be ideally suited to confine the noise of huge space boosters.

Government experts now believe that their earlier estimates—which foresaw a noise hazard from solid boosters breaking windows 25 to 30 miles away—were overly pessimistic.

They now feel that the acoustic factor will be no worse than that of the big liquid boosters which they intend to launch from the Atlantic Range facilities at Cape Canaveral. They also point out that AMR is more ideally suited for deep space operations.

Officials of the Air Force, NASA, and the Defense Department have all told congressional committees that neither the island equatorial launch site nor the mobile ship-launching pad are needed at the present time.

That position, they maintain, has not been changed by President Kennedy's order to go ahead with the manned lunar program. The only advantage of an equatorial launch site is that it avoids the present dog-leg operation required of equatorial shots from Cape Canaveral. It is far cheaper to use the Cape for such shots than it would be to build a new launch facility on some Pacific island, according to these officials.

The same sort of joint NASA-Air Force-DOD thinking applies to the Navy's proposal for a mobile launch pad. At the present time they claim there are just no foreseeable space missions requiring such a facility. ⌗

Hurricane hunter . . .

Tiros III to Advance Weather Work

NASA's latest meteorological satellite will pack two wide-angle TV cameras to improve on quality of pictures taken by its predecessors; three radiation experiments aboard

NASA WILL TAKE a giant step forward in its weather observation system this week with the planned launch of a *Tiros III* meterological satellite designed to provide information on the origin, development and movement of hurricanes.

If the launch is completely successful, the 285-lb. satellite will circle the earth every 98 minutes in a 400-mile-high orbit and—like its sister satellites, *Tiros I* and *Tiros II*—transmit thousands of television pictures of the earth's cloud cover to ground stations for weather analysis.

Tiros I, the first satellite in the weather observation system, transmitted 22,950 pictures in its 78-day life. *Tiros II* has transmitted more than 33,500 pictures and still operating after seven months. *Tiros III* is of particular importance because its expected lifetime coincides with the current hurricane season.

In an effort to improve the quality of the pictures taken, *Tiros III* will be equipped with two wide-angle television cameras. The earlier satellites in the program had one wide-angle and one narrow-angle camera.

Tiros III's wide-angle cameras will each use a one-half-inch Vidicon tube. An electronic beam will convert the stored pictures into a TV-type electronic signal which can be transmitted to ground receivers.

Connected to each camera is a magnetic tape recorder which can store up to 32 pictures during each orbit for transmission earthward when the satellite is within the 1500-mile command range of a ground station.

• **Some changes made**—Other innovations in the hurricane hunter include improved remote control programers for the electronic equipment and new transistorized circuits in the electronic clocks which trigger the cameras.

Other instrumentation — including beacon transmitters, attitude sensors, horizon scanners, telemetry circuits and a magnetic orientation control system—is identical to that used in *Tiros II*. Also as in *Tiros II*, the satellite contains infrared radiation experiments to measure sun-earth radiation relationships.

Power for the operation of electronic equipment is furnished by chemical batteries charged by more than 9000 solar cells mounted on the tops and sides of the spacecraft.

Tiros III will carry three radiation experiments, one scanning and two non-scanning. The scanning experiment consists of five sensors to map radiation in various spectral fields and is essentially the same experiment which was conducted by *Tiros II*. This experiment includes mapping of reflected solar radiation, long-wave radiation emitted from the earth and its atmosphere, temperature of the earth's surface or cloud tops and temperature of an atmospheric level varying with the amount of water vapor at an average altitude of about 25,000 ft.

One non-scanning type is the same as in *Tiros II* and *Tiros III*. It will provide gross heat-budget information by measuring reflected solar radiation and long wave radiation emitted from the earth and atmosphere.

The second non-scanning experiment is new, and was designed by Dr. Vernon Suomi of the University of Wisconsin. This experiment also will measure the gross heat budget, but the data will be more continuous—since the sensors can view the earth almost all of the time.

Tiros III is a cylindrical satellite resembling a large hat box, 42 in. in diameter and 19 in. high. It will be launched from Cape Canaveral with a three-stage *Thor Delta* vehicle. Its orbit will be approximately 400 miles high, at an inclination of 48 degrees from the equator, at speeds approaching 17,000 miles per hour.

With the exception of the infrared experiments, the satellite was designed and constructed by the Astro-Electronics Division of RCA, Princeton, N.J. RCA was also responsible for the special ground station equipment. Barnes Engineering Company, Stamford, Conn., provided radiation detectors under contract to NASA.

Overall responsibility for the flight rests with NASA. The operational phase of the flight is under the direction of the Goddard Space Flight Center. ¤

Douglas to Develop Rebound Orbiting

NASA has awarded a study contract to the Douglas Aircraft Corp. for developing orbital placement techniques and engineering design techniques for the Project Rebound spacecraft.

Douglas was one of nine companies submitting proposals to the Goddard Space Flight Center, which is directing the project. The contract amounts to approximately $450,000.

Rebound is a passive communications satellite program in which inflated balloon-type satellites—larger and more rigid than the 100-ft. Echo I—are to be placed in orbit with one launch vehicle. NASA says that a number of such satellites, spread around the world and acting as mirrors to reflect signals between ground transmitting and receiving stations, could eventually provide continuous communications on a global scale.

Present plans for Project Rebound are to put six satellites in orbit, using two Atlas Agena B vehicles, during 1963. The orbital placement technique to be developed by Douglas will attempt injection of the satellites into one common circular orbit 1500 and 2000 miles above the earth with equal circumferential spacing between satellites.

Communications experiments will be conducted from ground stations in the U.S. and other nations. Britain and France are constructing stations in Europe.

Laser Seen Replacing Radar In Space Navigation within Decade

GPL presents glowing report on laser studies at meeting of Institute of Navigation; Carbonara is winner of 1960 Thomas L. Thurlow Award

by Charles D. LaFond

WILLIAMSBURG, VA.—Lasers will be capable of outperforming radar for space navigation. Used in spacecraft within the next decade for distance and velocity measurements over cislunar range, such systems will be accurate to one part in 100,000.

For a system using pulsed emissions, only two-ft.-diameter transmitting and receiving mirrors would be required. Estimated average beam power would be roughly 66 watts, bandwidth might have a frequency spread of one part in 10^{13}, and a beam spread of about 0.2 second arc.

These conclusions were recently presented here in a paper co-authored by Dr. Cecil B. Ellis and Dr. Ivan A. Greenwood, both of GPL Division, General Precision, Inc., and delivered before the 17th Annual Meeting of the Institute of Navigation.

The paper summarized results of nearly two years' study by the authors of the potential and practical applications of laser (light amplification by stimulated emission of radiation) systems.

This year's meeting saw a marked increase in attendance with total registration exceeding 400, according to ION officials. The technical program covered all aspects of navigation—underwater, surface, air, and space.

Whether the increased emphasis on underwater and space navigation techniques or the attraction of reconstructed Colonial Williamsburg served to bolster attendance is debatable. Nevertheless, each session during the three-day meeting drew large and enthusiastic audiences.

The Thomas L. Thurlow Award for the outstanding contribution to the science of navigation during 1960 was won by Victor E. Carbonara, former president of Kollsman Instrument Corp. Carbonara was honored for his work in the design and development of the first automatic celestial navigator for aircraft (first units were used operationally in the B-52 and B-58 during 1960).

• **Laser research**—Dr. Ellis told M/R that GPL began its paper studies on lasers and optical pumping mediums almost immediately following first announcement of Hughes' ruby-laser effort.

Initially company-funded (well over $100,000 so far), GPL later studies were supported in part under a Rome Air Development Center, USAF, contract investigating the whole field of advanced communications technology.

There are four principal virtues in the use of lasers for space navigation, said Ellis:

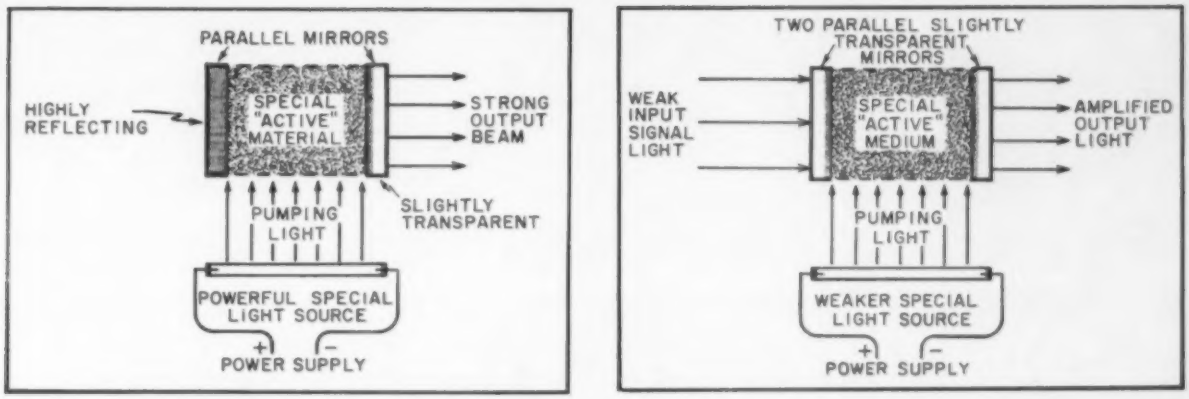
1. They are small in size and entirely self-contained.
2. They provide long operating range at low power.
3. Reception is essentially noiseless.
4. Measurement is extremely accurate.

A laser transmitter, he said, will permit an extraordinary degree of parallelism and narrowness of frequency bandwidth in its output beam. The divergence angle of the beam eventually will approach 1 microradian, or about 0.2 second of arc.

Moreover, bandwidth in low-power beams now have a frequency spread of only a few parts in 10^{11}. In the next several years, Ellis believes that a spread of 1 part in 10^{12} or 10^{13} will be reached even at high-power levels.

• **Receiver next?**—A major piece of hardware— and still a missing link—is the development of a laser receiver. This, Ellis said, will be forthcoming shortly. (Note: It is reported that GPL will announce development of a working laboratory laser receiver within the next several months. GPL officials neither confirm nor deny the possibility, but it is known that the division numbers itself among the many who are driving hard in this area.)

Ellis indicated that such a receiver would be very similar in construction to that of the transmitter. In the laser configuration of the transmitter, two precisely parallel mirrors are employed separated by the pumping medium



SIMPLIFIED DIAGRAMS of transmitting (left) and receiving (right) laser systems.

(such as synthetic gem ruby). One is almost a perfect plane reflector; the other is slightly transparent for emitting the output beam.

In a receiver, he said, both mirrors would be slightly transparent.

A major problem, of course, is that the receiver must be matched to the transmitter. That is, the receiver mirror spacing must be in resonance for the wavelength of the transmitted signal.

Further, the axes (perpendicular to the mirrors) of both receiver and transmitter must be parallel within a very close tolerance to prevent the received light ray from "walking off" the mirror edges before amplification.

However, Ellis asserts that this inherent discrimination serves to reject extraneous background light and provides a nearly noiseless receiver. This holds true even in a receiver aligned with the sun.

Internal noise of a receiver, created by the omnidirectional glow of the laser active material during operation, is similarly negligible, Ellis said. Thermal noise is no problem at all—since the system would operate at temperatures below that necessary to emit energy in the visible portion of the spectrum.

• **Navigation measurements** — Distance measurements using laser techniques, Ellis feels, will be similar in approach to that by radar. Pulses will be transmitted and the reflection delay measured. Scanning will be accomplished also with techniques standard to radar.

The great difference, however, is in accuracy and the differences in antenna size. With its narrow beamwidth angle and lack of thermal noise, the laser system will permit operation out to distances now impossible with radar systems capable of being borne in a spacecraft.

Ellis suggested that a typical laser system of the future, using 2-ft. reflectors and having a 66-watt average beam power, would permit ship-to-ship distance measurement in space at 160,000 km to an accuracy of 1 part in 100,000.

Such systems, said Ellis, will have a probable efficiency of 10%. Even allowing for all the associated electronics needed for determining distance, power requirement during the measurement period would be about 800 watts.

Pulse rate over such a distance would be 1/sec.

• **Orientation problems**—Initial orientation for the hypothetical navigation system, said Ellis, would probably require use of a 2-ft.-dia. optical telescope. Once aligned roughly with the telescope, angular scanning of the laser beam about the target would permit precise alignment.

Ellis emphasized that the laser will be capable of out-performing radar only after it is aimed properly. It is not better than conventional microwave for search missions.

It would be a simple matter, Ellis pointed out, to employ the same 2-ft. mirror for transmitting, receiving, and for the sighting alignment.

Lasers will offer another great advantage, Ellis stated, in determining altitude measurements between vehicle and a relatively small area on a target planet. Using microwave techniques with a comparatively broad beam, the resulting measurement actually is an average of distances over a wide range of points on the surface illuminated.

• **Velocity determination**—The use of Doppler frequency shifts with a laser system could be performed with great accuracy, according to Ellis. It requires a "tunable" receiver but, with a laser pulse transmission between two objects having relative motion, the frequency change will be many times the bandwidth of the echo. This then would be a large and measurable effect.

Ellis feels that tuning capability required by the receiver would be for response to a frequency up to one part in 100,000 away from the transmitted signal frequency.

He suggested that tuning could be accomplished by employing a small gas-filled space between the end of the laser active medium and one mirror. By changing gas pressure (and thus the density), the velocity of light through the inert gas would change. This would change the conditions for resonance between mirrors.

This would permit scanning the expected frequency range until the return signal was received and subsequently amplified.

The advantage in this approach is the avoidance of shifting the mirrors. With the accuracy of parallelism required between reflectors, adjustment is impractical, he said.

• **Moon landing**—For velocity measurements near (1600 km) the moon or when approaching the moon for a landing, Ellis presented an analysis of a suitable laser system using a 2-ft. reflector.

With the spacecraft moving at about 2300 knots parallel to the lunar surface, an average transmitted beam power of 40 milliwatts would provide magnitude and direction of velocity every 8 seconds, Ellis said. These figures would have an accuracy to 0.1%.

At 50,000 km and all other conditions the same, average transmitted beam power of about 40 watts would be required.

In time, Ellis believes that laser systems of this type will be built weighing about 10 lbs. and occupying about one cubic foot of space.

• **When?**—Conceding that today's laser transmitters are all laboratory research devices and receivers are publicly non-existent, Ellis feels practical prototype laser systems will be available in from 3-4 years. Today, some 16 different approaches being taken toward laser hardware development. Most of these will yield useful systems for communications, navigation, and even long-range detection and tracking.

Operating hardware will be ready by the time it is needed for future spacecraft in this decade, Ellis asserts. ⌗

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Technical Countdown

ELECTRONICS

Saturn Computer Selected

Librascope Division of General Precision, Inc., reportedly is the winner in its competition with IBM for the contract for guidance computers in the early *Saturn* booster program. The system will be a modified version of the *Centaur* digital computer developed by Librascope. Selection was made after nearly a year of test and evaluation by NASA's Marshall Space Flight Center in Huntsville. Award will be announced officially in about four weeks.

First Laser Receiver Developed?

Industry informants say GPL Division of General Precision may have produced the first laboratory-type laser receiver. In any event, look for the company to announce a big advance in laser technology within two months.

Army Pushes Radar Research

A mile-high mountain-top radar beacon is being used by U. of New Mexico scientists in an Army program to study effects of the atmosphere on radar beams. The precisely located beacon on top of Goat Mountain provides a signal to the main station, 45 miles away, to allow researchers to accurately measure the errors caused by varying atmospheric conditions.

Miniaturization Advances Revealed

A solid-state microwave transmitter, developed by General Telephone, is 1/7 the size of conventional transmitters. GT says the unit has 11 times the life expectancy and 10 times the frequency stability of predecessors. It was developed for the Air Force for possible space applications. Output power is two watts at S-band frequencies (1700-2300 mc). Not to be outdone, General Electric has demonstrated a miniature transmitter which uses a single tiny ceramic oscillator. Transmitter and power supply can be held in one hand. Range of the unit, with 30 mw at 7300 mc, is about 50 feet.

ASTRONAUTICS

Meteoroid Protection Being Studied

"Meteoroid bumpers" to protect space vehicles against damage by particle collisions are being studied by General Dynamics/Convair under a $54,000, 1-year NASA contract. Study will involve theoretical research in meteoroid impact in terms of mass and velocity and experiments in hypervelocity impact, using shaped explosive charges to achieve impact velocities up to 20,000 feet per second.

Astronomer Praises Electronics Industry

Radio astronomers are more than satisfied with the present state of the electronic art, according to one JPL scientist. Astronomers admit that the electronics they use are better than really needed—and that the chief roadblock is now the physical difficulty of extracting information from space.

Earth-Venus Meter Stick Studied

NASA is studying an in-house proposal to use the distance between the Earth and Venus as a means of discovering new planets or new moons of old ones in our solar system. Using the almost perfect radar reflectivity of Venus and the accurately determined distance between the two bodies, the perturbations of the two orbits would be studied and, from this data, the approximate size and location of previously unknown bodies could be determined.

ADVANCED MATERIALS

Water Bullets Puncture Steel

Drops of water traveling at 3400 mph penetrate thin pieces of metal like a rifle bullet and leave sizable dents in thick sections of copper and stainless steel. Westinghouse researchers also note a burst of light at impact, but the nature of this phenomenon is not known. Purpose of the experiments is to evaluate the effect of water droplets on rapidly moving surfaces such as turbine blades, aircraft and missiles.

Tungsten Insert Process Perfected

Aerojet engineers have perfected a hot-worked tungsten insert process that starts by flame-spraying the metal on a mandrel, continues through a 5000°F two-hour heat-treat and ends with a hot spinning operation which works the insert exactly to the desired contour.

High-Temp. Strain Gages Advanced

Bureau of Standards researchers have upped the resistivity of ceramic cements used to fasten strain gages to hot surfaces. A technique has been devised to increase the resistance to ground by applying a fired-on ceramic coating to the grid of a specially developed unbacked gage.

PROPULSION

Centaur Insulation Jettisonable

Engine insulation for *Centaur* consisting of 10-ft.-diameter and 12-ft.-long sections will be jettisoned just prior to ignition. The half-inch panels use a freon-polyurethane foam in a honeycomb core covered by fiberglass. A helium bath between the engine and the insulation reduces heat transfer.

ASW ENGINEERING

Navy Looks to Bigger Hydrofoils

The U.S. can use current technology to build a 300-ton hydrofoil with speeds up to 60 knots, says Ralph Lacey of the Navy's BuShips. He adds that a 500-ton craft with a 60-knot capability could be produced in 2 years with an accelerated program, and BuShips is looking ahead to hydrofoils of 1000 tons or more with speeds up to 100 knots. Lacey disclosed that Boeing's BCH-1, 110-ton, 50-knot experimental hydrofoil will be ready for sea trials next year.

Hydroskimmer Contract Due by Fall

The Bureau of Ships is reported planning to let a contract this fall for a 20-ton ground effect craft. It will employ a full peripheral air curtain for lift and two air screws for horizontal drive.

LIFE SUPPORT

Wasteless Food Considered

Soviet scientists maintain that it is possible to produce special foods which the human organism can consume completely without leaving a residue. Russian biologists are considering using hydroxides of lithium and calcium to absorb CO_2 during short-time manned space flights.

Zeus Resistors Made at Rate of One

Western Electric spent own funds to design and develop fully automated computer-directed line

by James Trainor

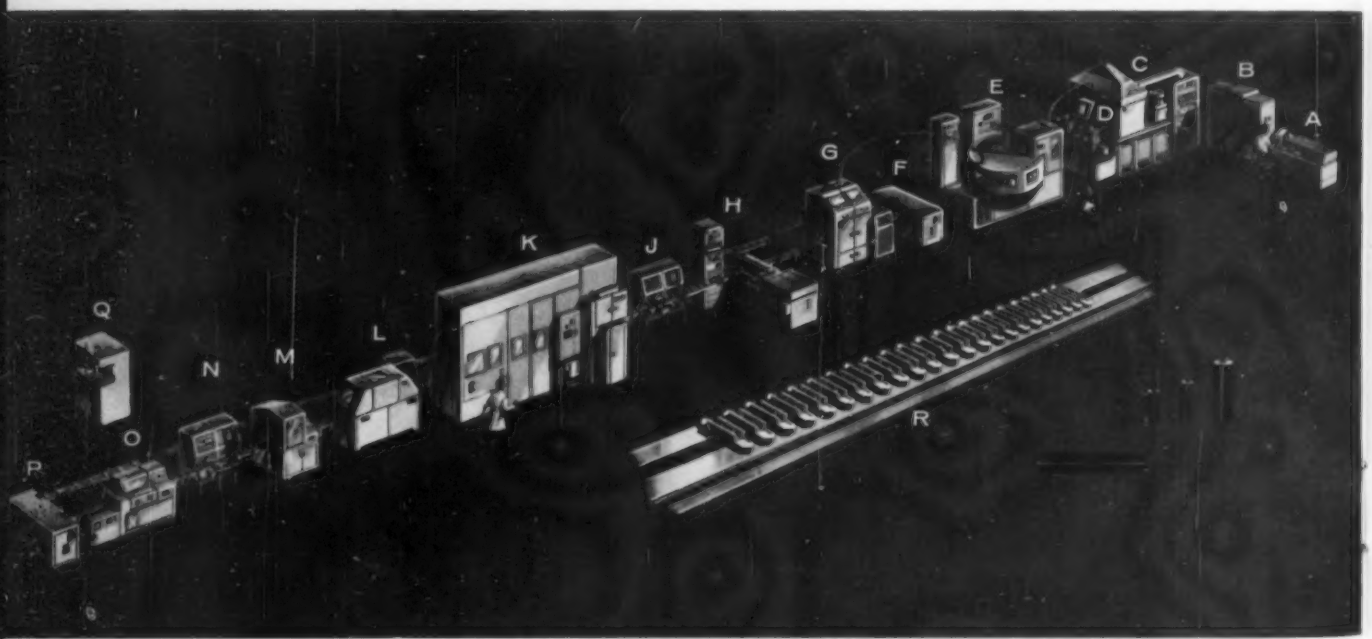
WINSTON-SALEM, N.C.—Carbon deposited resistors—untouched by human hands and made to order in just three seconds—are pouring from a unique computer-controlled production line.

The 110-foot-long facility, revealed for the first time last week, was developed by Western Electric Co.'s North Carolina Works to meet stringent military requirements for the *Nike-Zeus* anti-ICBM (M/R, Jan. 30).

In a single engagement, the *Zeus* system will call into play 2,000,000 of these elementary components. In addition, they must function under any and all environmental conditions with a rate of failure not exceeding one in 200,000,000 hours—a reliability 10 times that already achieved by conventional semi-automatic and manual production techniques.

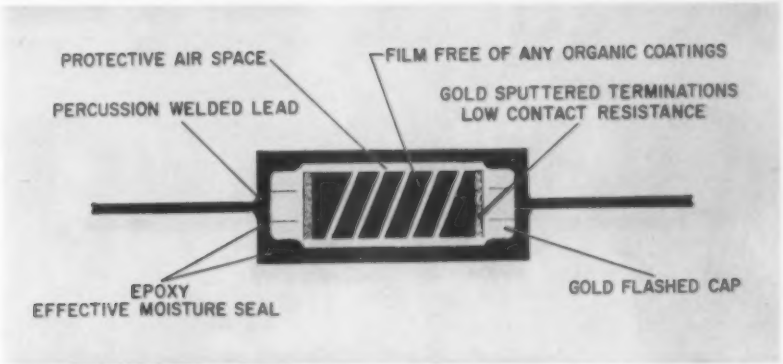
Before Western Electric could automate production to *Zeus* specifications, it had to find out why resistors had failed in the past. Detailed analysis isolated the three main culprits: inorganic material in contact with the resistor had an aging effect on the component; persons in manufacturing the resistor left their contaminating mark which acted to change the value of the resistance element; and, finally, given enough time, it is almost impossible to keep moisture from seeping into the resistor.

• **Two million per year**—Once the trouble spots were isolated, Western Electric engineers designed and built a fully-automated, computer-controlled production line in about six months. The whole job, paid for out of Western Electric's own pocket, cost $300,000 to design and develop and another $312,000



ARTIST'S CONCEPTION of Western Electric's fully automatic, computer-controlled production line for turning out a reliable, completely sealed deposited carbon resistor every three seconds. Shown are the 11 machine stations, the computer with its input and output circuits, a detail of the conveyor line (center) and examples of finished resistors (lower right).

Each 3 Sec.



CUTAWAY of carbon resistor shows active element and its protective covering.

for the machines and computer.

The line—the first completely automated process to manufacture any discrete electronic component—consists of eleven machine stations, the computer and its control cabinets, and a percussion cap-lead welder. It is capable of turning out approximately 2,000,000 resistors a year on a one shift basis.

At the heart of the system is the computer—a Librascope LGP-30, modified for "on line" use—with its input and output circuits which had to be extensively redesigned in order to control the programing, setup and feedback control of the individual machines.

To produce the four wattage sizes—¼, ½, 1 and 2—and the large number of resistance values required, the computer performs four basic functions:

—Programs production requirements for a month, completely scheduling and arranging the work according to the power sizes and resistor values to be produced.

—Analyzes control statistically from data plotted at three critical points in the automated process and determines if a trend is developing.

—Formulates information to detect any drift from manufacturing tolerances and, if such a drift develops, calculates new setup information for the appropriate station from previously stored data.

—Provides the initial setup of wattage size at eight machines and resistance value at six.

• **Production sequence**—The nucleus of the resistor is a tiny ceramic core produced by the American Lava Co. from processes developed by the Bell Telephone Labs. Fed automatically from a hopper at the beginning of the line, the core moves along a conveyor belt to the coating machine at a speed controlled to within an accuracy of 0.1%.

As the core moves through the coating machine, it is rotated to insure that the crystalling carbon is deposited uniformly. Inert nitrogen gas is continuously flushed through the machine to prevent oxygen contamination of the material. Decomposed methane gas at a temperature of 2100°F is used for the coating process. After the carbon is deposited on the core, the piece is cooled to room temperature and moved through the first inspection station.

The three parameters which govern the resistance coating value—the speed of the core through the machine, the pyrolysis temperature and the flow of methane gas—are all controlled by the computer through a feedback loop around the furnace.

A 100% inspection is given the core using the Kelvin bridge principle before it moves to the terminating machine which sputters a gold contact over each end.

• **Gold capped**—At a pick-up station the core is fitted with a mask, depending on its power size, to protect the center during the sputtering. It is then loaded onto one of the machine's 36 vacuum stations and covered with a bell jar which is pumped to a vacuum of 10 microns and then backfilled with argon gas at 90 microns.

A gold cathode sputters the ends of the core protruding from the mask with gold particles for approximately 50 seconds. The deposited layer of gold is made uniform by rotating the core on two rollers for maximum exposure.

Operating on a demand basis, the capping machine loads the resistor core onto a turret to hold it in position while the tiny gold-plated, hexagonal caps and leads are pressed over both ends. The capping force is sufficient to weld the gold plating of the cap to the gold on the ends of the core.

Also computer controlled, the capping machine uses two different capping assembly heads and three different sizes of caps for the four resistor wattage sizes.

The helixing machine cuts a precise value for the resistor by rotating the properly chucked resistor against a diamond-impregnated wheel. The computer-controlled bridge monitors the cutting of the spiralled resistance groove and rejects any chipped or unevenly-coated resistor or any resistor that reaches value before 75% of its length is used or fails to reach value in its full available length.

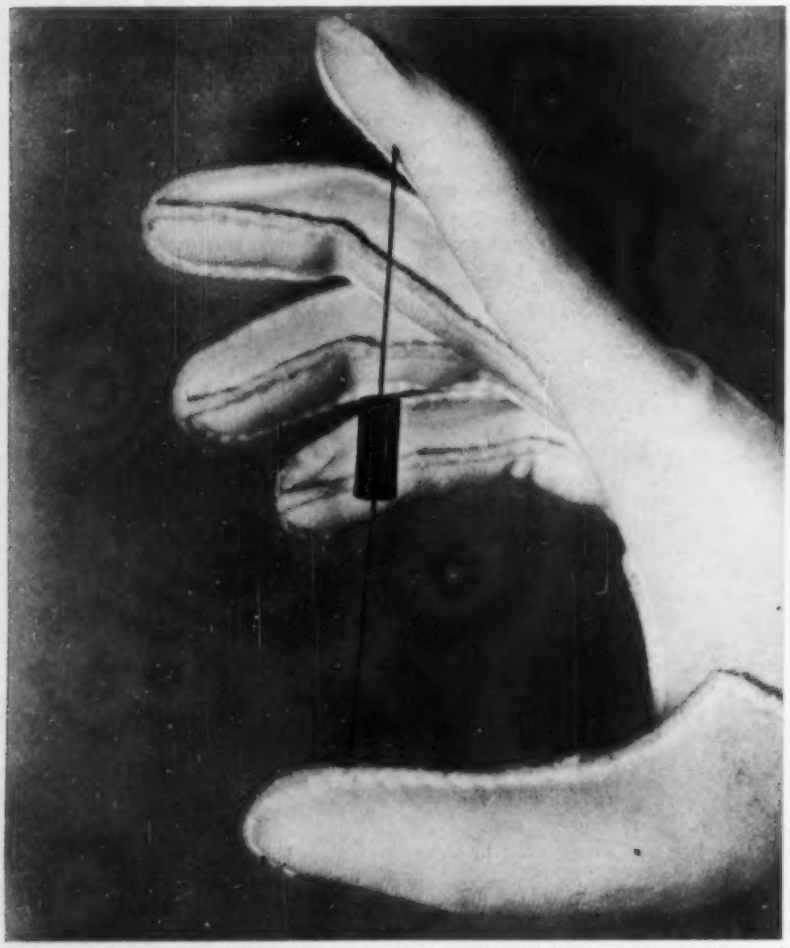
To achieve the three-second spiralling speed—a fraction of that commonly used—a carefully balanced magnetic counter weight was used to hold the movable chuck assemblies against the diamond cutting wheel. A wheatstone bridge then inspects the resistor to insure that the proper value has been achieved and rejects the defective ones.

• **Leak detector**—The resistor is then fitted with a precured epoxy shell and two partially cured epoxy pellets and placed between two resilient rubber chucks before entering the encapsulating machine. (The resilient chucks prevent trapped air from causing leaks in the finished resistor.) Cured for 17 minutes in a 350°F oven, the partially cured pellets soften and form an effective seal with the precured shell. The curing process is terminated by passing the resistors through cooling water jets. A cartwheel detector checks each resistor to find any ballooning or cartwheeling of the resistor ends due to heating.

To detect any leaks in the protective coating the resistors are passed through a 165°F hot water bath containing a wetting agent to prevent surface bubbles from clinging to the resistor body. Ten photoelectric cells—capable of detecting leaks as small as 2×10^{-6} cc per second—watch for air bubbles indicating a leak. A special memory device then rejects defective resistors as they leave the bath.

The resistor's next stop is the marking machine which stamps the wattage, resistance value, production lot number and date on the encapsulated resistor. Using a modified offset printing technique, the machine has 1,700,000 marking values for resistance and 45 different code numbers. To be respon-

EVACUATED BELL JARS are used to sputter gold particles on ends of resistor core with gold cathode. Gold is later reclaimed from sides of jars for future use.



THE FINISHED PRODUCT—A resistor able to withstand the pressures of time and environment for 23,000 years. Acceptable yield is currently approximately 65%.

sive to computer control a bulky typehead was used with the blanket roll and inking rolls mounted on a planetary gear arrangement.

• **Yield is 65%**—The final inspection station checks the resistance value to ±1% and provides feedback control to the helixing machine to compensate for shifts in resistance value caused by the heat of encapsulation.

The acceptable resistors are then packed into lots of 10 and 15 by the packing machine and inserted into styrofoam blocks—the final process in this fully automatic operation.

An automatic machine outside the line percussion-welds the copper-coated leads to the gold flashed brass cap at a rate of 3600 parts per hour. The weld is made by an extremely short (200 microseconds) arc of high intensity.

Another line—capable of producing ⅛ watt resistors at twice the rate of the first one—has also been built but is not yet in operation.

Although the design goal of the automated line is an acceptable resistor yield of 85%, this has not as yet, been reached. The current yield is approximately 65%. Western Electric engineers, however, feel that the design goal will be reached and, perhaps, surpassed by improving the quality of ceramic cores used on the line.

In the event that the *Nike-Zeus* is approved for production, Western Electric officials estimate that ten such lines would be needed. However, if *Zeus* is not authorized, the resistors from this line and those still being hand-made will be used for the needs of the Bell system and should prove adequate for that task.

With the advent of the fully automatic, computer-controlled resistor line, the company officials said, the way has been paved for many more electronic components to be automatically manufactured including transistors, capacitors and inductors. ⌗

British BMEWS Crews Training in New Jersey

MOORESTOWN, N.J.—British engineers are learning how to operate the Ballistic Missile Early Warning System (BMEWS) in preparation for the day when the third and last BMEWS station goes "on the air" at Fylingdales Moor in Yorkshire, England, in late 1962 or early 1963.

Employes of RCA (Great Britain) Ltd., are studying under British direction to become instructors for the several hundred engineers and technicians who will be needed to operate the Fylingdales installation.

RCAGB is an associate company of Radio Corp. of America, prime contractor for BMEWS through its major Defense Systems Division here. ⌗

Potential of Spark Plugs Ignored

New developments push spark rates above 1200 per sec.— increased use is anticipated in liquids; limited future in solids

by W. Johnston
AC Spark Plug Division, General Motors Corp.

THE RAPID EVOLUTION in propulsion technology has brought about a multitude of ignition systems and devices which all but ignore the most familiar igniters in the U.S.—spark plugs.

Spark ignition systems are usually considered and then eliminated for some reason which may not be completely valid. As with any missile component, there has to be a trade-off among the advantages and limitations.

For instance, pyrotechnic systems, using electrically initiated solid-propellant charges, are small and simple but entirely unsuited to many applications because of their single-start ability. They may ignite prematurely during storage.

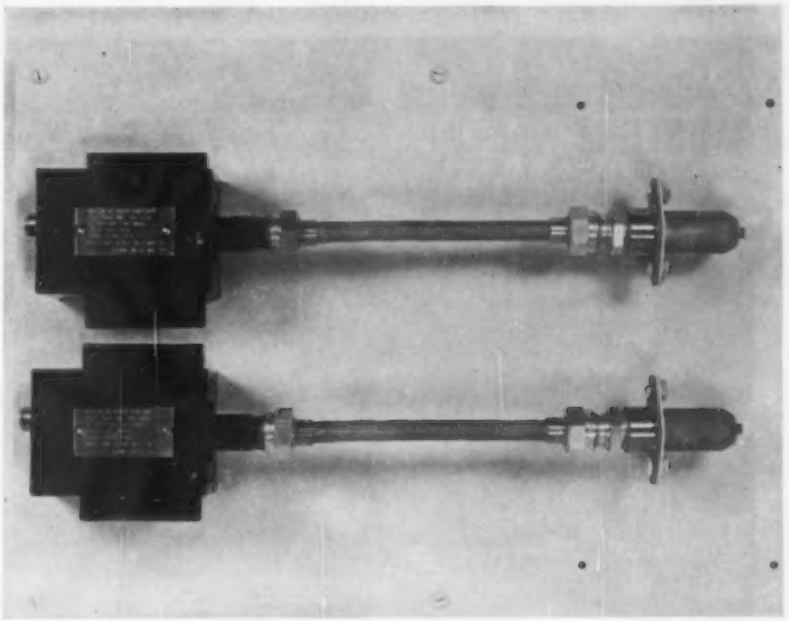
Hypergolic ignition, reliable in most cases, is not completely satisfactory because some hypergolic materials are not self-igniting under all conditions, and in some cases specific impulse may be limited by restriction to certain fuels and oxiders. The start-up and shut-down procedures are very critical and can result in severe detonation if the propellant flow rates are not correct—and there are storage problems.

Catalytic ignition systems are not complex, but they result in large heavy engines, in many cases require regenerators or preheaters, and are contaminated or burned up during the combustion process. The system is also relatively expensive.

Hot-spot or hot-wall systems using glow wires or heat sinks are also quite simple. But they require large amounts of power, have slow responses and can be fouled by combustion deposits.

• **Conventional plug out**—The mechanism of ignition by sparks is probably the least known of all the systems. The common high-tension spark plug, used in automobiles and other reciprocating engines, has several serious limitations.

In this type of plug the demand voltage of the gap depends upon the material in the gap and its density. At pressures above atmospheric the demand voltage increases as pressure increases. At pressures below atmospheric the demand voltage decreases as pressure decreases, until a certain pressure is reached at which the demand voltages increase rapidly; at high vacuums extremely high voltages are required.



TWO TYPICAL ROCKET IGNITION systems manufactured by AC Spark Plug Division include exciters, igniters and interconnecting cables.

The variation of demand voltage of the gap and the high voltages used, in the range of 15 to 25 KV, requires extremely good insulation in the cable, igniter, and exciter. The presence of moisture adds to the insulation requirements.

The vacuum of outer space necessitates very high voltages. If high spark energies are required, the exciter becomes quite complex and inefficient. In addition, the high-tension igniter is subject to fouling by the combustion deposits.

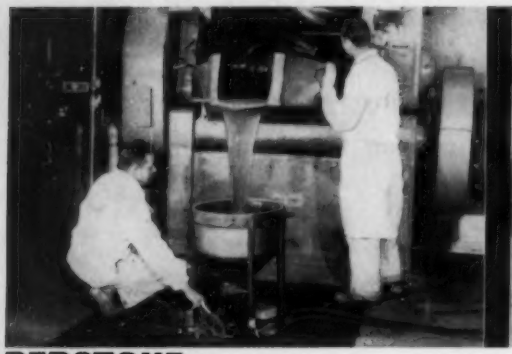
A spark ignition system not subject to these limitations is the creepage gap system—also known as surface gap, shunted surface gap, or low-tension system. This type differs from the high tension igniter in that a semiconductor is used in place of an air gap.

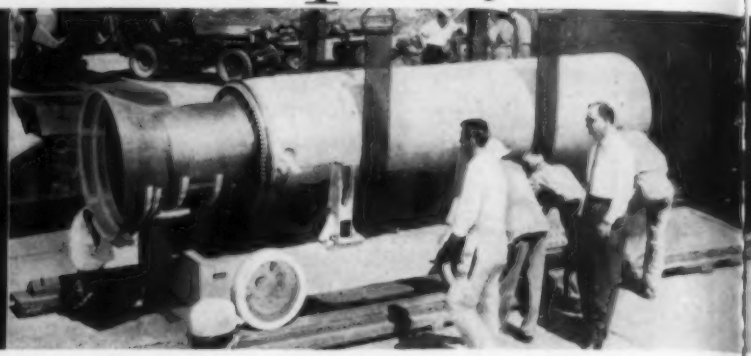
In a creepage igniter, the spark travels from electrode to electrode across the surface of the semiconductor. The exact mechanism of this spark is not known, but the gap requires a relatively low voltage to break down, usually between 1000 and 3000 volts.

• **Constant demand voltage**—The low voltage requirement of the creepage unit reduces the insulation requirement of the system, helping to eliminate the altitude flashover problem. The creepage gap also is substantially unaffected by the pressure at the gap or the material in the gap region. The demand voltage is about the same at 500 or 1000 psi, or at high vacuums, as it is at atmospheric conditions. In addition, the igniter is difficult to quench with

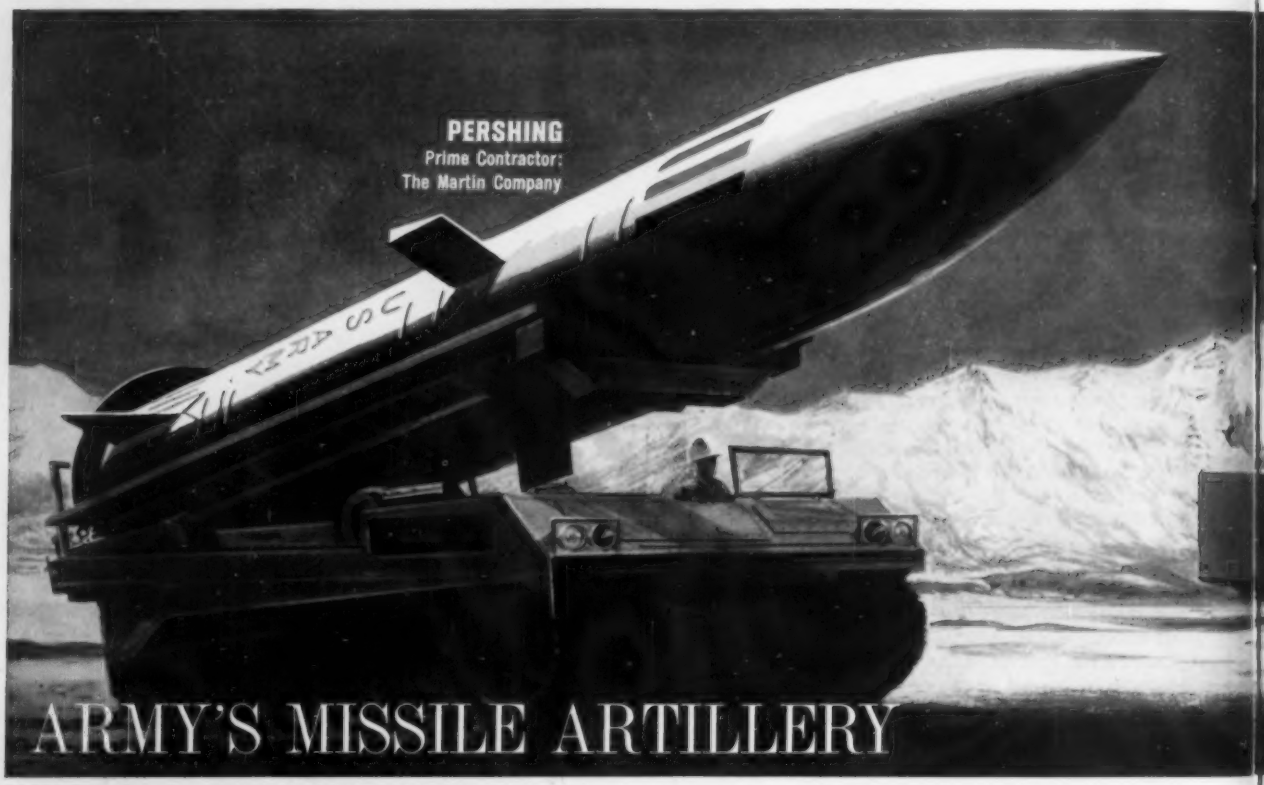
(Continued on page 41)

RELIABILITY in depth, from





REDSTONE *Working as part of Army's Ordnance team, Thiokol's Redstone Division conducts research into propellant formulation and solid propellant motor development. Experiences—gained in the labs, through developing prototype engines, and at firing bays continuous since 1949—have resulted in many significant breakthroughs . . . providing a steady increase in size, thrust and performance of solid rocket motors.*

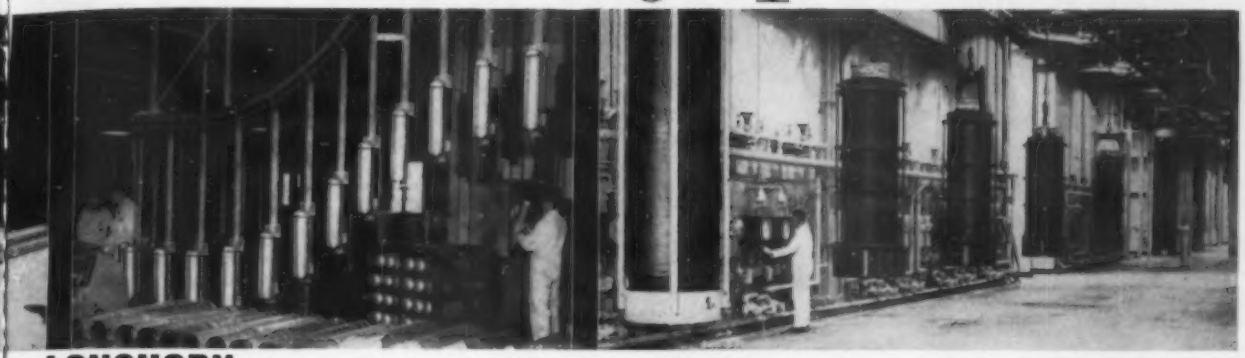


ARMY'S MISSILE ARTILLERY

ARMY

In close cooperation with the Army and prime contractors . . . Thiokol designs, develops and produces propulsion systems in wide variety to meet the most stringent military requirements. The associations are distinguished by a series of major breakthroughs in propulsion engineering—beginning with small rocket motors for tactical field use and carrying through to massive powerplants for anti-missile and satellite application. All have checked out in static firings and

research through production



LONGHORN *Motors for the Lacrosse and for the developmental Sergeant and Pershing missiles, and for other major systems—all boasting remarkably high reliability scores—move into smooth mass production at Longhorn. Incorporating most advanced methods of manufacture and quality control, Longhorn's total productive capability has yet to be challenged. Other Thiokol Divisions provide additional scientific and production capabilities.*

flight tests with virtually 100% reliability. All have contributed mightily to advancing the total state of the art. Additional capabilities for Army's advanced thinking are provided by other Thiokol Divisions. Utah, for large engine production—RMD, for sophisticated liquid systems — and Elkton, for diversified special motors.

Through fluid programming of assignments, and strategic enlargement of facilities for research, development and production, Thiokol maintains a live capability to meet any current and future propulsion challenge — military or space.

THIOKOL

THIOKOL CHEMICAL CORPORATION, Bristol, Pennsylvania
Rocket Operations Center: Ogden, Utah

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The World's Biggest 'Instant Ocean'

by William Beller

"INSTANT OCEAN" is the latest in a series of major new hydrodynamic facilities developed in the wake of the nuclear submarine.

The U.S. Navy late last month dedicated what it calls "the largest simulated ocean in the world" at the David Taylor Model Basin in the Maryland suburbs of Washington, D.C.

The facility is designed to test exotic naval craft such as hydrofoils, hydroskimmers and ground-effect machines—as well as more conventional vessels. A similar "ocean" is already operating at the Netherlands Model Basin, and another is being completed at the Admiralty Experiment Works in England.

Interest in advanced test facilities has pyramided with the advent of a host of new problems presented by the speed, quietness and range of the nuclear submarine and the potential high speed of surface-skimming craft.

• **Industry promised time**—The U.S. Navy's facility is housed in a new building covering five acres and sharing its quarters with a "rotating arm" basin 260 ft. in diameter.

Shakedown tests of both the ocean and rotating arm basins are now going on. By late summer or early fall, the facilities are expected to be ready to do useful work. Although they will put an end to occasional open-lake hydrodynamic testing they will have the advantage of practicality in helping to devise new water-going military vehicles.

Although Congress has said that the Model Basin facilities should be available to the maritime industry, government work has left little time for projects of private shipbuilders and naval architects. Now that the new facilities are almost ready to carry some of the research load, Navy officials are promising to give much more time to solving problems for industry.

• **Just like the sea**—The Maneuvering and Seakeeping Basin is the more dramatic of the two new facilities.

Pneumatic wavemakers located on two adjacent concrete banks of the rectangular basin are able to generate a variety of waves: regular and irregular long-crested ones, short-crested ones, and combinations. The entire range of ocean seas can be simulated up to those corresponding to gale-force winds. Data can be obtained relating to the maneuverability and control of surface ships, submarines and other vehicles operating in smooth and rough waters.

The waves' energy is absorbed by concrete lattices located on the banks opposite the pneumatic wavemakers. In this way, wave reflections are held down almost to zero.

The greater part of the 240-ft. by 360-ft. basin is 20 ft. deep; however, a 50-ft.-wide "deep-sea" section running almost the basin's length is 35 ft. deep, and useful for testing relatively large submarine models.

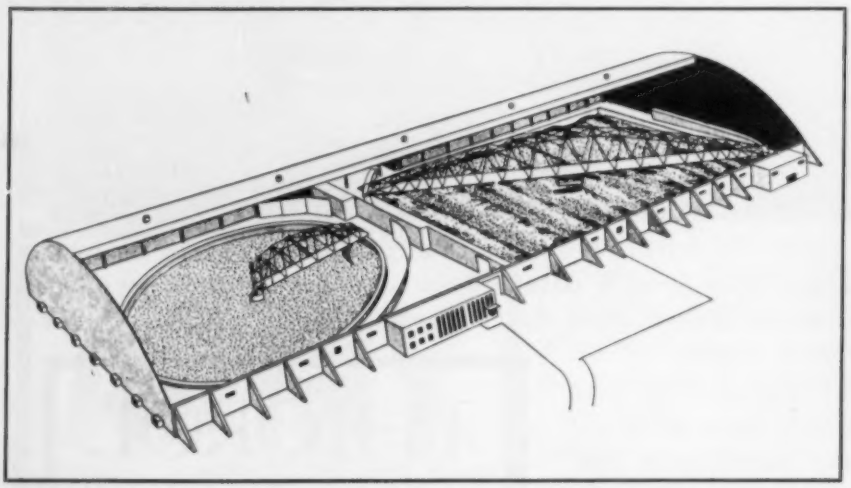
An ingenious arrangement of supporting structure and shuttling carriage permits test models to be towed in head or following seas at any angle from zero to 90 degrees and with simulated speeds far higher than those of existing craft.

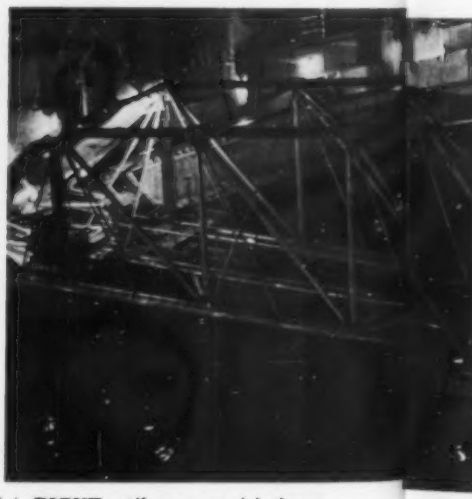
This is done by spanning the basin's length with a steel-trussed bridge—mounted on tracks—which can not only traverse half the basin's width but can be rotated up to 45 degrees from the basin's longitudinal axis.

An aluminum-tubed carriage for towing models is suspended from tracks attached to the bridge's underside. Maximum carriage speed is 15 knots. Trolley wires running the bridges' length carry the power for ship model motors, carriage drive, instrumentation and control.

In this way, through appropriate rotations and translations of the carriage and through selected energies supplied to the wave-making units, an infinite variety of sea conditions can be imposed on test models—all the way up to simulated waves 100 ft. high and 2500 ft. long, breaking in any direction and with a large range of relative speeds.

• **Round and round it goes**—The second of the two new facilities—the Rotating Arm Basin (RAB)—is needed to give "rotary" coefficients, so important for determining the stability and control characteristics of maneuvering or turning vessels. These coefficients are usually approximated or extrapolated from other data when the speeds of surface and underwater craft are rela-





LEFT: *Cutaway view of Rotating Arm Basin (left) and Maneuvering and Seakeeping Basin (right).* **RIGHT:** *Albacore model shown*

tively low. But, when design speeds of water-borne craft go into the 35-knot and above regime, more accurate ways to get the rotary coefficients must be used.

The Navy says that RAB will be used to find out the directional stability, maneuverability and control of high-speed submarines, torpedoes and surface ships. RAB is also seen providing design data for high-speed hydrofoil craft and ground-effect machines.

RAB, in essence, is a arm pivoting around a small island located in the center of a 260-foot diameter, water-filled basin.

The arm, an aluminum truss, rides at its outer periphery on two wheels driven by a pair of electric motors. It radially spans the basin and supports test models by a system of tracks, model tow carriage, positioning apparatus, towing struts and force balance.

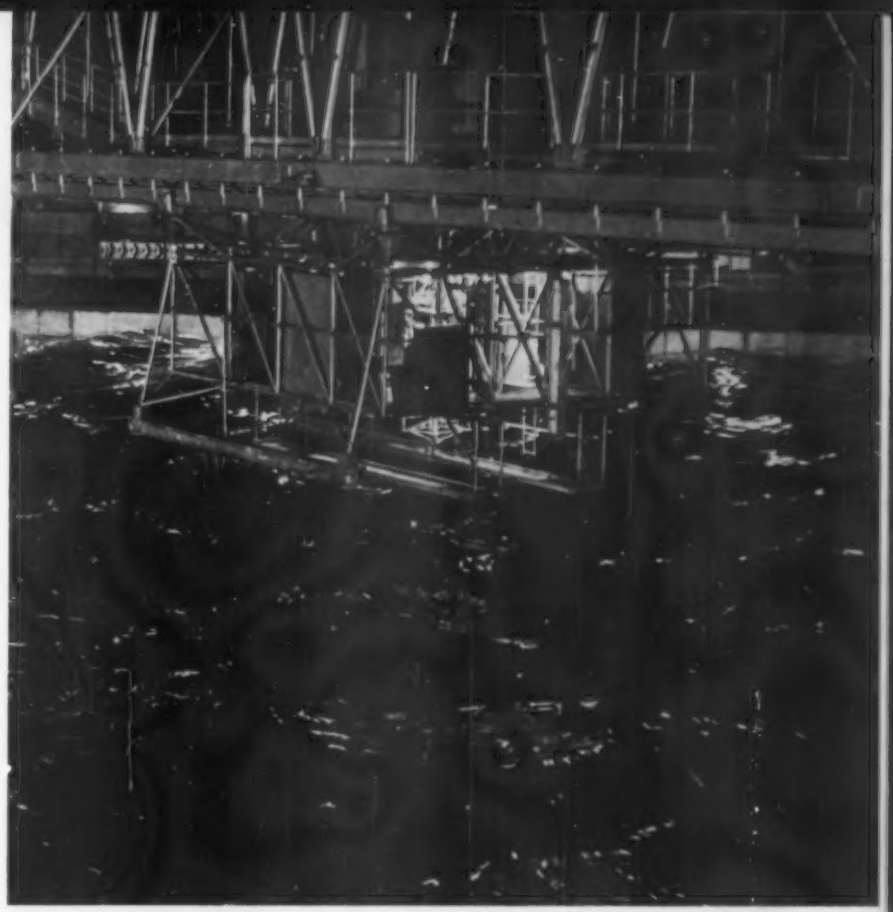
Models submerged in the 21-ft.-deep basin are positioned in yaw, roll and pitch from a remote control station.

A steady-state arm speed of 30 knots at the 120-ft. test radius is attained in less than one-half revolution of the arm; and 50 knots at the same radius it attained in two revolutions.

The Rotating Arm Basin and the Maneuvering and Seakeeping Basin will give the Navy highly reliable test data for the design of high-speed ships. Such data has been hard to get because, in the past, model tests could be run only in smooth water or in water with waves that a real ocean would disown.

Now that realistic waves will soon be generated in the new facilities, and higher model speeds introduced. the Navy can design craft better able to take severe evasive action, to serve as a stable platform for launching guided missiles or aircraft, and to go at relatively high speeds just above the water's surface, through it, or below it. ⌗

suspended from the RAB's pivot arm.



STEEL-TRUSSED BRIDGE, mounted on tracks, supports carriage for towing models through seas simulated in Maneuvering and Seakeeping Basin. Pneumatic wavemakers here create choppy waves (above) or regular rolls (below). Wave reflection is minimal.

Incremag Counting System Opens New

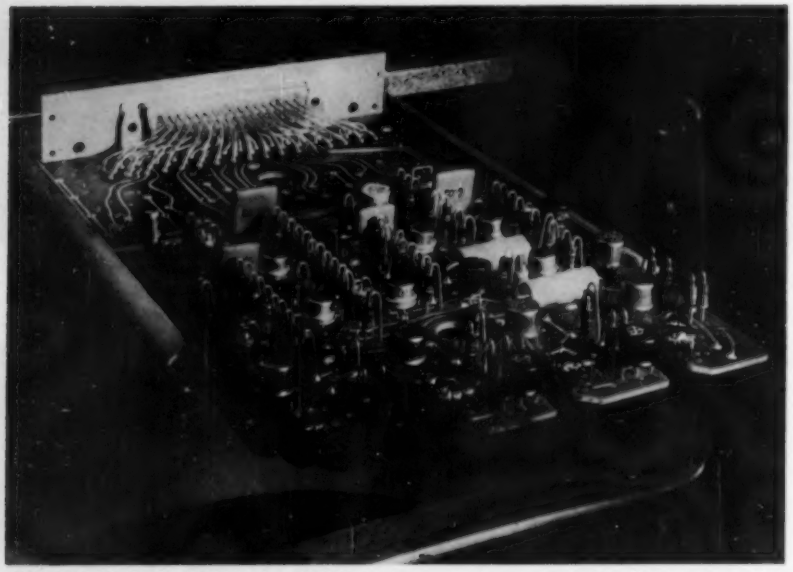
Firm forms new division to handle sales expected from concept based on toroidal, wire-bound magnetic coil

by John Judge

STAMFORD, CONN.—A magnetic counting system, currently circling the earth in the highly successful *Tiros II* weather satellite, is opening a wide new field for its creator, General Time Corp.

The system's nucleus is a transistorized magnetic counting-dividing circuit that delivers an output pulse after having received a predetermined number of periodic or random input pulses. It then acts as a counter, a frequency divider or an integrator.

Trademarked "Incremag," the development is compatible with existing digital or analog systems after certain conversions or matching circuitry changes.



WIRE-BOUND MAGNETIC CORES in foreground constitute the Incremag portion of a partially completed satellite programer.

• **Flux bucket**—The basic Incremag counting stage consists of a small toroidal magnetic core having a square B-H loop. This core is wound with a number of turns of fine wire. Two transistors and four resistors complete the circuit.

The core holds a fixed quantity of flux. This quantity is reached through an integral number of "counts." When the required number of constant magnitude pulses have been applied, the core will be driven to positive saturation.

The fall of the last input pulse triggers a second transistor in the circuit, which then drives the core out of positive saturation and back to negative saturation. When this stage is reached, the circuit is returned to its initial state.

The output from this counting stage may be used to fill another counter. As many Incremag stages as desired may be cascaded to provide a train of any desired count. An internal circuit is used to provide the required constant volt-second pulse to the first counter, regardless of the characteristics of the input pulses.

Incremag can be used to perform many of the functions formerly executed by binary components—with greater simplicity and reliability.

The potential of Incremag is so great that General Time has formed a new division to market the concept.

Other items pouring out the firm's research laboratories include a true rotary solenoid, and an Incremag satellite programer.

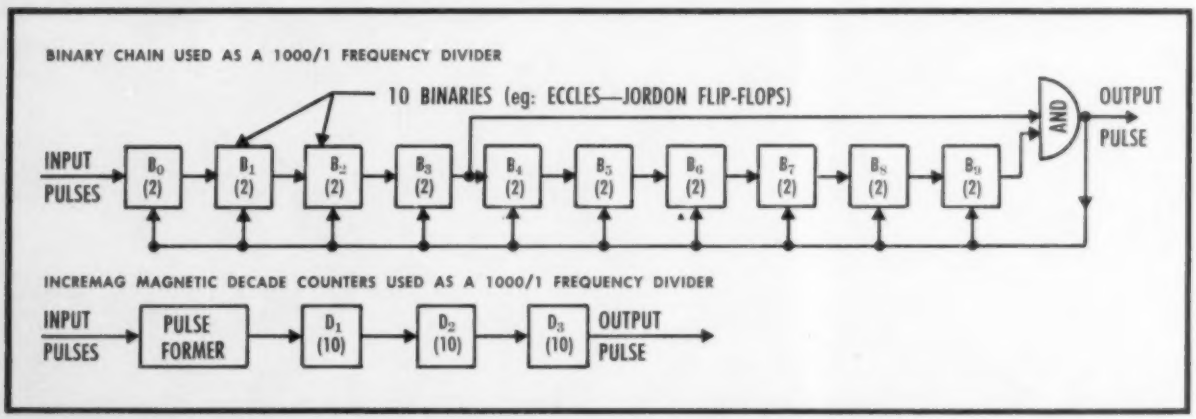


DIAGRAM SHOWS how Incremag can perform frequency dividing job, formerly done by binary chain, with greater simplicity.

Market Areas for GT

• **Generic marketing**—Incremag illustrates the General Time approach to the space business—and to the firm's growing industrial market. For years, General Time has been intimately associated with clocks and watches. Baby Ben, Westclox and Seth Thomas are part of the nation's vocabulary.

The firm no longer regards itself as a clock manufacturer. Instead, long-range plans are predicated on the concept "Time" and any path indicated by planners and researchers will be followed as long as it is related, however remotely, to this generic view. There is a discernible movement from mechanical capabilities into electronics, but without sacrificing the manufacturing and engineering background developed during the long history of the firm and its parent companies.

The basic thought is that in-house developments will lead GT into new areas. The company has no intention of diversifying by acquisition. This does not rule out purchases if such are deemed necessary or if the move is highly complementary to management's concept of the market.

A systems approach is being developed in certain areas. GT's Stromberg Division is producing and marketing a data collection and transmission complex called the Transacter. One current idea is to combine the transacter system with the Incremag and come up with a system for programing and automation.

The underlying theme is to develop marketable components while moving toward a systems capability. With this in mind, GT is eyeing the industrial area in automation control, programing and data processing. But the outlook covers a projected 10-to-15-year period.

The research activity at General Time is more applied than basic. Two laboratories, one in Stamford and the other in a Chicago suburb, work in harmony with the five U.S. manufacturing divisions.

Besides the *Tiros* series, GT is involved in projects with several prime contractors to the Air Force, Army, Navy and National Aeronautics and Space Administration. Most of the work is either classified or proprietary. The firm is pursuing studies in solid-state and other "no moving parts" areas related to missile/space and "time." ⁂

NBS' Rephrasing Searcher

AN ELECTRO-MECHANICAL information searching device incorporating the element of feedback has been developed by the National Bureau of Standards.

The system permits the searcher to rephrase or change his questions in the light of the previous answer. This feedback element is difficult to build into large, complex and centralized information systems.

The NBS system uses a "peek-a-boo" punched card technique based on its "microcite" concept. Each punched card represents an index word, and the hole positions identify documents pertaining to the index word. In ordinary use, the hole position is interpreted as a document serial number by means of a coordinate grid printed on the card or on a transparent overlay.

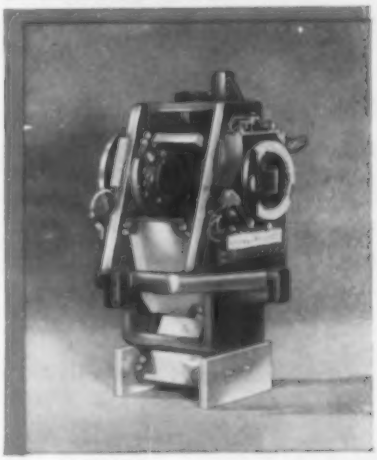
The new microcite is designed for sets of 18,000-document cards with corresponding abstracts carried in a 15-in.^{2} photographic film matrix. In operation this film matrix, appropriate to the card-set being searched, is selected and placed on a drum. The operator places the cards on an illuminated area of the machine and manipulates two control wheels to position a set of cursors on each unobscured hole.

Turning the control wheels causes rotation and translation of the drum so that as the cursor is set on each hole, a full-sized focused image of the citation and abstract corresponding to that hole is projected on a screen in front of the searcher. As he proceeds, the operator can obtain a copy of the abstract by thumbing a recording lever. Alternately, he may note the serial numbers on punched or printed paper tape.

The electrically coded serial-number output available for this transcription could also be fed into a document storage machine which would provide copies of complete documents in response to serial-number input.

The tool in operation at the NBS is designed for 18,000, but it could search millions of documents. The machine was developed under the sponsorship of the Department of Defense. ⁂

PRECISE STAR TRACKER



A celestial navigation system called for a tracking device capable of establishing a line of position within an accuracy of 300 feet. Kollmorgen came up with a constant deviation elevation system that positions a movable mirror, in relation to the fixed elements, to a repeatable accuracy of better than 5 parts in a million.

This compact package represents a combination of highly precise optical and electronic units in a housing only 6 x 6 x 10 inches. Kollmorgen's project from concept to installation, it is a typical demonstration of the company's scientific, engineering and manufacturing skills in optics, electronics, mechanics. Example: the precision optics (a prism and two mirrors) are of Kollmorgen manufacture. So, too, are the Inland torque motor*, the gearing and other precision-machined parts.

Our motive in this message: Kollmorgen offers proven capabilities in optics, electronics and precision machining of metal components . . . capabilities which could solve your problems in missile tracking, fire controls, navigation, or . . .?

Present us with a problem.

*Product of Inland Motor Corporation of Virginia, a Kollmorgen subsidiary.

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Satellite Might be Used to Verify

Stanford's Prof. Schiff is proposing that a gyroscope be orbited to look for the axis precession which must exist under Einstein's laws

by Robert L. Forward

A SATELLITE experiment now being proposed could uniquely verify Einstein's Theory of Gravity. It is scientifically simple, but it poses difficult engineering problems.

The basis of the experiment, suggested by Stanford University Professor L. I. Schiff, is this: Under Newton's laws, a spin-stabilized torque-free gyroscope in orbit around the earth has its spin axis pointed constantly in the same direction. But, according to Einstein's laws, the axis precesses approximately one microdegree per day. Schiff proposes looking for this precession, the expected value of which can be calculated only by using Einstein's Theory of Gravity.

There have been only three "crucial" experimental tests of the differences between the Einstein Theory of Gravity and the Newton Theory of Gravity. These three experiments are: the bending of light rays as they pass near the sun due to the gravitational pull of the sun on the photons, the decrease in frequency (energy) of the photons as they climb up out of the gravitational field of the earth, and the calculation of the correct shape for the orbit of Mercury.

In each of these cases, it can be shown that Newton's theory gives the incorrect result and Einstein's theory agrees with the experimental results. Thus it is known that Einstein's theory gives a better description of gravity than Newton's theory.

• **Patchwork theories**—However, as Schiff and others have pointed out, Einstein's General Theory of Relativity is only one of the many possible theories which go beyond Newton's theory that all masses attract each other *instantaneously* with the force law

$$F = -\frac{G M m}{r^2}$$

All the experimental results can be explained by using these other theories of gravity, so that the "crucial tests" do not distinguish between Einstein's theory and these other possible non-Newtonian theories of gravitation. For instance, the two experiments concerning the effect of gravitation on light rays can be calculated by using Newton's law and the experimental fact of special relativity that light has energy and therefore mass ($E = mc^2 = hf$).

Even the non-Newtonian perturbations of the orbit of Mercury can be explained away if one modifies the Newtonian idea of gravity by saying that gravitational effects travel at the speed of light, not instantaneously as Newton assumed in the formulation of his theory.

The reason, of course, that Einstein's theory is preferred over these other ad hoc, patchwork theories, is that Einstein's theory of gravitation not only includes the ideas of special relativity and the finite propagation of gravitation, but has connected them in a rigorous mathematical formalism which is free from possible internal contradictions.

What Schiff wants to do is find an experimental test of a gravitational nature that will be predicted correctly only by Einstein's theory. He has proposed that a spinning torque-free gyroscope be put into orbit and the direction of its axis determined over a period of time as it rotates about the earth. The spinning satellite will have to be a nearly perfect, homogeneous sphere.

According to the Newtonian concepts of gravitation and inertia, if we put a torque-free gyroscope in orbit around the earth, line it up on one of the fixed stars and then start it rotating, it will become spin-stabilized and will remain pointed at that position in space for all time.

Schiff has calculated this same example of a spinning torque-free gyroscope using Einstein's theory of gravitation. He finds that for an orbit in the earth's equatorial plane, the spin axis of the satellite will precess due to two gravitational effects that are contained only in Einstein's theory. One of these effects is due purely to the presence of the mass of the earth near the satellite;

Robert L. Forward, "General Relativity for the Exp." Proceedings of the IRE, Vol. 49, May, 1961. Some of the material and figures from this paper were used with the permission of the IRE.

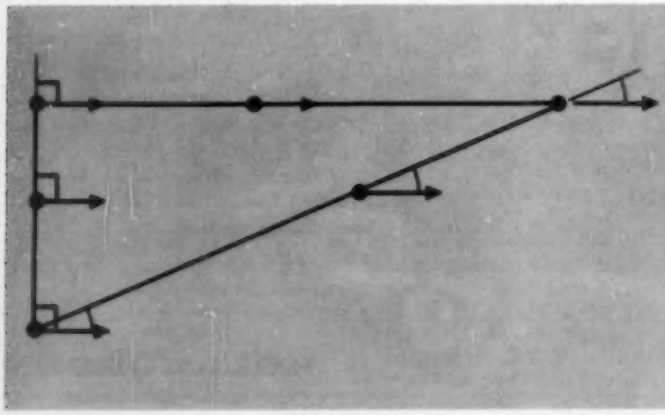

Figure 1

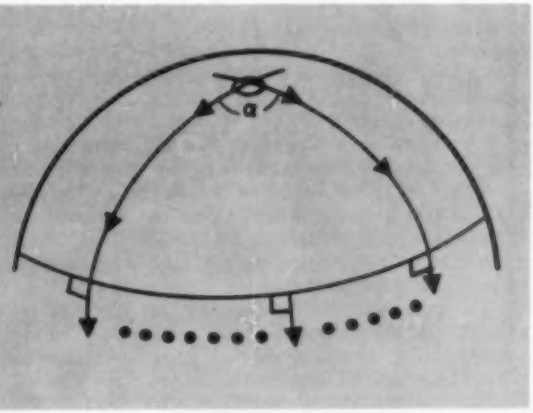

Figure 2

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Einstein's Theory of Gravity

the other effect depends upon the fact that the earth is rotating. Both of these effects are quite complicated, but fortunately they can be explained qualitatively by analogies with more familiar effects.

• **Effect of space curvature on a satellite**—The precession of a spinning torque-free gyroscope in an orbit around a large mass is due to the non-linearities in the Einstein equations for the gravitational field.

The easiest way to look at these non-linearities is to assume that the mass of the earth, besides causing the usual Newtonian gravitational field, also causes the space around the earth to be curved. We should be familiar with the problems of operating in a curved space, since we live on a two-dimensional curved space—the earth. A straight line on the earth is the great circle route, because it is the shortest distance between two points in that two-dimensional space.

If we make a triangle with these "straight lines," we find that the sum of the angles in the triangle can range from π radians (180°) to 5 π radians (900°) depending upon the size of the triangle.

Also, the ratio of the circumference of a circle of latitude to its "radius" (distance along the surface to the North Pole) can vary from 2 π radians (360°) near the pole where the curvature of the sphere can be ignored, through 4 radians (229°) at the equator, where the "radius" from the pole to the equator is ¼ of a great circle route.

Since one of these circles has less than 360° in it, if we send a vector around this circle, the vector will not return to the starting position pointing in its original direction.

It is difficult to show this concept with a circle, but we can easily show it using spherical triangles. Suppose we are on a flat surface and we place a test vector at one corner of a triangle. Then, very carefully keeping the angle between the vector and the appropriate side of the triangle constant, we traverse the perimeter of the triangle and return to the starting point (see Fig. 1).

The test vector obviously returns to the starting point with the initial orientation. Now try this same simple experiment with a vector moving about on a spherical triangle (shown in Fig. 2). It will be obvious even to a flatlander inhabiting the surface of the sphere that the vector has precessed through an angle α as a result of its parallel translation around a closed path in the two-dimensional space. The angle α will depend upon the amount of curvature of the space, the size of the triangle and the number of times the test vector has gone around the triangle. It should be obvious that the same effect will occur for a polygon and, by extension, for a circle.

Because we are three-dimensional beings, we can see the curvature of this two-dimensional space and understand the effects. However, a two-dimensional being living on a sphere would not be able to comprehend the curvature of his space—even though he could measure it and describe it mathematically by doing experiments such as this. We are in the same trouble when we try to comprehend curvature in a three-dimensional space. We have no way of picturing three-dimensional curved space so we have to trust our measurements and mathematics.

Thus we should now understand that because Einstein's theory says that the mass of the earth causes the three-dimensional space around the earth to be curved, then a test vector (axis of a spinning satellite) moving in a circular orbit in this curved space will experience a precession of its axis.

• **Effect of the earth's spin on a satellite**—The other type of precession, that of a spinning, torque-free gyroscope in an orbit about a spinning mass, is due to the interaction between the spins of the two bodies. It was shown in a recent article in the *Proceedings of the IRE** that Einstein's theory of gravitation is directly analogous in many ways with electricity and magnetism.

For instance, the usual Newtonian gravitational field of a mass is analogous to the electric field of a charge. It was also shown that there exists a gravitational equivalent to the magnetic field which arises from moving or rotating masses. Thus, just as a rotating charged body will generate a dipole magnetic field, a rotating massive body will generate a dipole field which is the gravitational equivalent of the magnetic dipole field. And just as two magnetic dipoles interact and cause troques on each other, two rotating masses such as the spinning earth and a spinning satellite will cause gravitation-like torques on each other. This torque will cause the spin axis of the satellite to precess.

• **Precession rate**—For those who are interested, the equation for the precession of the spin axis of a spinning, torque-free satellite in an equatorial orbit about the earth is

$$\Omega = \frac{3GM}{2c^2r}\,\omega_{orbit} - \frac{GI}{c^2r^3}\,\omega_{spin}$$

where M, I, and ω_{spin} are the mass, moment of inertia, and angular velocity of the earth and r and ω_{orbit} are the orbital parameters of the satellite. The first term, which is the largest, is due to the effects of space curvature, the second term is due to the interactions of the spins of the earth and the satellite. If we put in numbers we get:

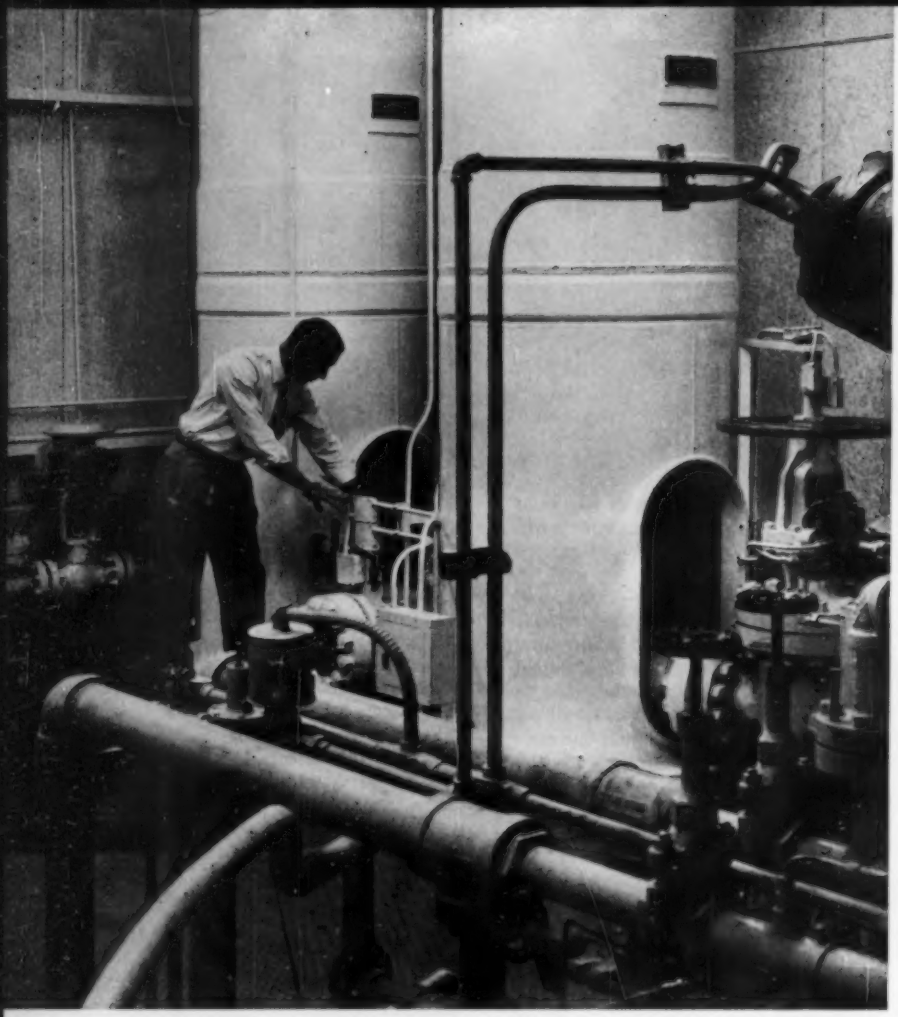
$$\Omega = (9.0 - 0.11) \times 10^{-13}\ rad/sec.$$

and we see that the spin interaction term is a small percentage of the space curvature term. This precession of about 10^{-6} degrees/day would be very difficult, but not impossible, to observe.

The problems of instrumenting a satellite to perform this experiment are not trivial. The spinning sphere could contain no internal instrumentation, since the necessary differences in densities of the apparatus would result in torques due to the gravitational fields of the sun, moon and earth which would hide the Einstein effects. Also, since there would be no way to insure that drag effects would be uniform and cause no torques, these would have to be eliminated by a protective shield.

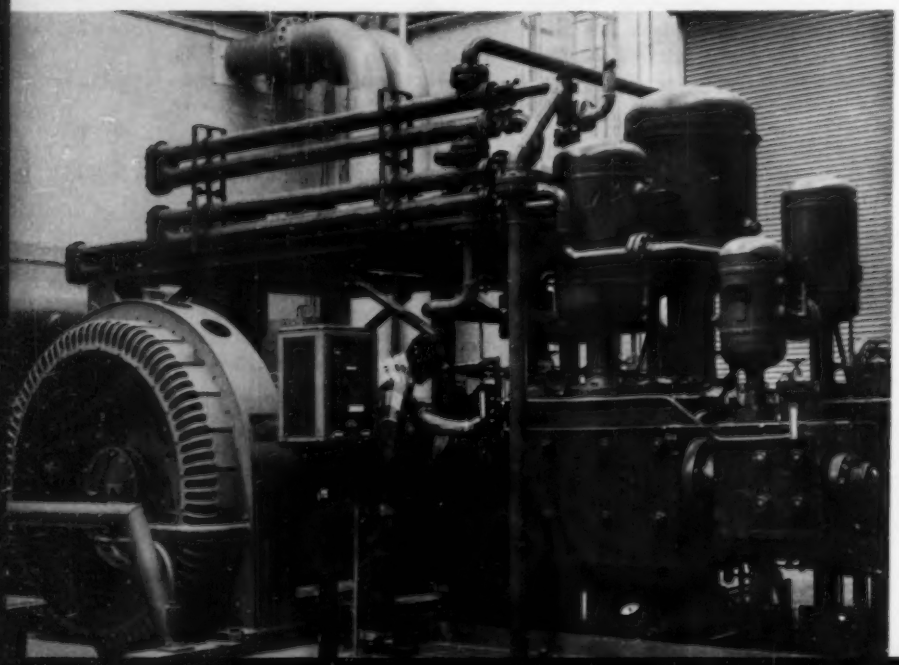
What is needed is an apparatus designed along the lines of the Orbiting Astronomical Observatory. It would contain the necessary telescopes to determine a reference frame with respect to the stars, the readout devices to determine the orientation of the spinning sphere, a large chamber in which the sphere would float protected from meteorites and atmospheric drag, and vernier rockets to correct for torques and drag so as to keep the external apparatus centered about the sphere.

Whether this can be done now with an instrumented satellite is a problem that can only be answered after a considerable amount of engineering study. In any case, it is an ideal project for the first manned space laboratory. ¤



ABOVE: *Twin air storage tanks hold 500 cu. ft. of El Segundo atmosphere at 3500 psia when ready to blow down. The tanks project through the roof. The air supply is remotely monitored and controlled from a concrete-protected control center near the test section in the same building.*

BELOW: *Air is pumped into the storage tanks for about one hour before daily runs are started, by a non-lubricated, carbon-ring compressor that supplies 1800 cfm. Entering air is not treated to alter its basic chemical composition; the compressor does not further contaminate the working medium because of design.*



$2-million addition . . .

Industry's

Nike-Zeus model is slated for first study in facility which uses long nozzles and small throats to obtain its elevated Mach numbers

EL SEGUNDO, CALIF.—Industry's largest hypersonic tunnel will begin operational testing here at the Douglas Co. when a *Nike-Zeus* model is studied at Mach 6.

The new test facility, opened last week, is a two-million-dollar addition to the subsonic and supersonic tunnel facilities at Douglas' Aerophysics Laboratory. The Mach 10 tunnel, which took three years to build, was contracted by Diversified Builders, Inc., and designed by Douglas and Sandberg-Serrell Corp. of Pasadena.

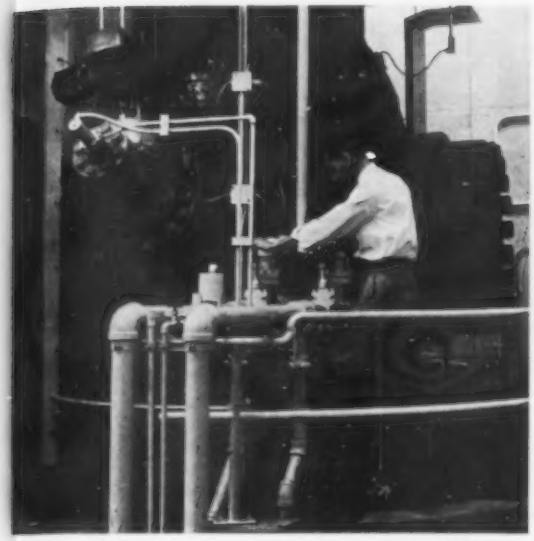
By changing supersonic nozzle sections, Aerophysics can make runs at Mach 6, 8 or 10 with atmospheric air. Higher Mach number tests are possible on helium, if some modifications are made. However, these modifications are not now scheduled.

According to Dr. James S. Murphy, Assistant Chief, the higher Mach numbers of 6, 8 and 10 for the new facility are obtained from nozzles that are quite long and very small at the throat—a fabrication problem leading to anguished moans from the machinists.

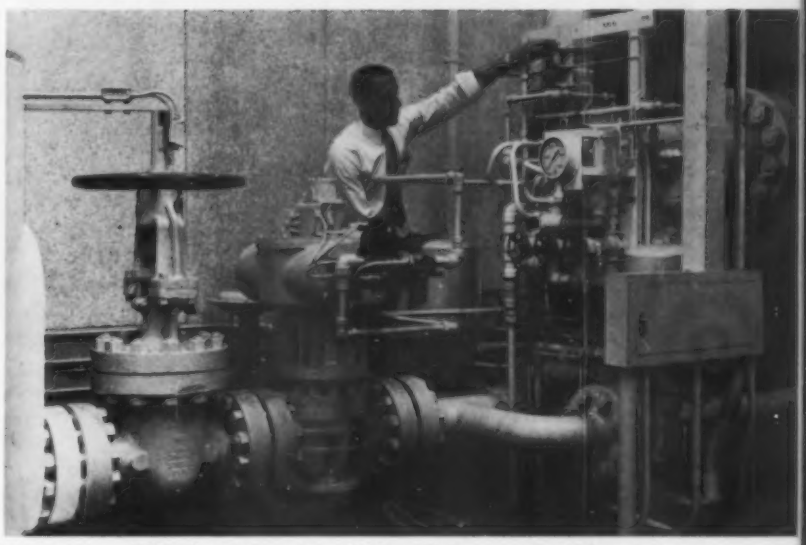
The solution adopted was to electrodeposit the walls of the nozzles around a polished aluminum mandrel of the precise curvature. This method of building up nickel to a ⅝-in. wall thickness required starting the process three to four months before delivery was expected. Because of the higher operating temperatures, the Mach 8 and 10 nozzles were built up around a throat insert machined from a beryllium/copper alloy to give sufficient structural integrity.

The heated air from the stilling chamber and intermediate spools accelerates as it flows through the nozzle throat and continues to gain velocity as it roars through the divergent portion, reaching the desired Mach number as

Biggest Hypersonic Tunnel at Douglas

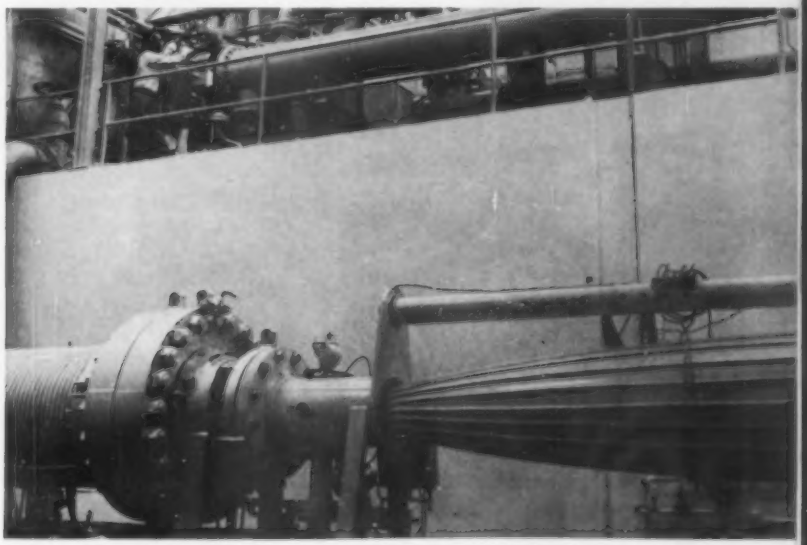


LEFT: *Next in supply system comes 100-ton pebble bed heater through which chosen portion of 3500-psi air flows in downward direction on way to therm mixer where hot and cold streams are blended to obtain required temperature in test section for the Mach number in use. The ⅜-in.-diameter alumina balls are maintained at 2800°F at top of bed.*

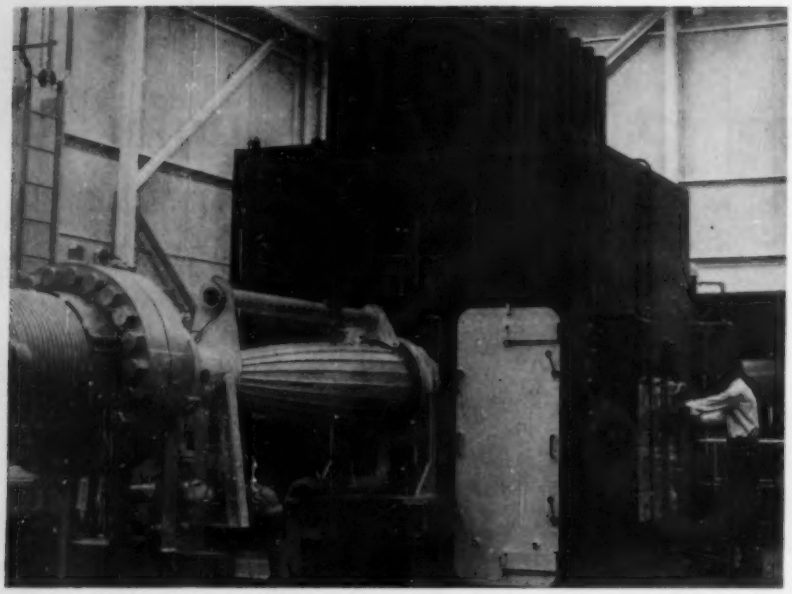


RIGHT: *Giant valves dividing high-pressure air flow between pebble bed heater and thermal mixer are automatically controlled to provide flow into test section at desired temperature. A 3000-psi hydraulic subsystem provides muscle for operating all valves and giving fast response. When ready to make run, operators in remote control center activate circuit.*

LEFT: *Upstream components—thermal mixer, mixer valve, and heater—have previously been preloaded with full-pressure air. Heated air passes through an inner wall into test area of building. It flows through a Douglas-designed stilling chamber that smooths out turbulence and other disturbances before entering the supersonic nozzle section.*



RIGHT: *Low-pressure cooling system—40 psig of water at 2000 gpm—also cools test-section plenum chamber, test-section diffuser, spools (nozzle adapter sections), and ejector plenum. High-pressure cooling system providing 400 psig at 600 gpm keeps nozzle throat, support strut for test models and diffuser throat from overheating.*



HEATER AIR FROM STILLING CHAMBER and intermediate spools accelerates as it flows through nozzle throat, gains velocity through divergent portion, reaching desired Mach number as it blasts into test chamber. Here at nozzle exit lies dimension used to classify tunnel. Mach 6 nozzle expands up to diameter of 25 in., hence term "two-foot" hypersonic tunnel. Largest diameter in present set-up—27 in.—belongs to Mach 10 nozzle.

it blasts into the test chamber.

A maximum run time of four minutes can be obtained at the lower Mach number, allowing the complete flight pattern of a missile or space system to be simulated. Remote controls rotate and roll the models as desired.

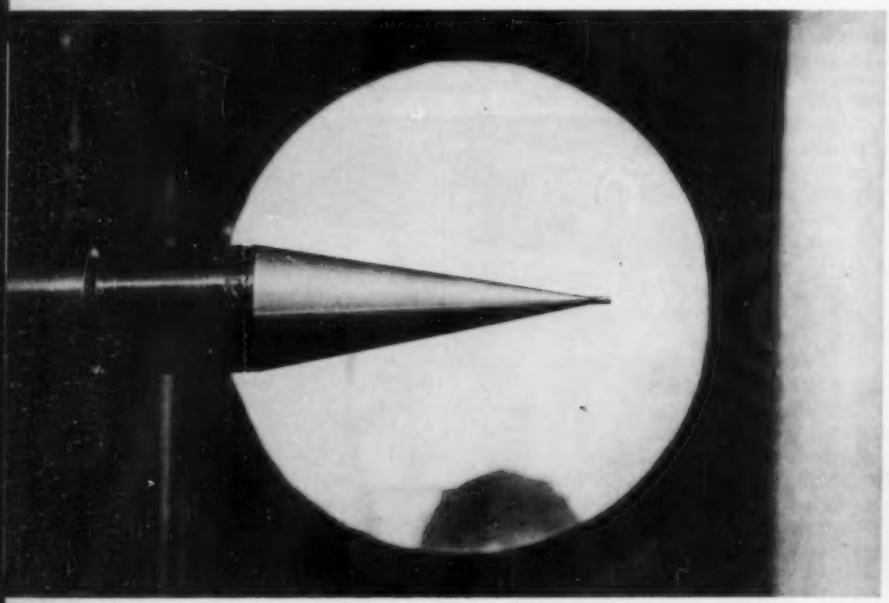
The maximum waiting period of one-half hour is required to bring the storage tanks and pebble bed heater up to operating conditions after the high Mach runs.

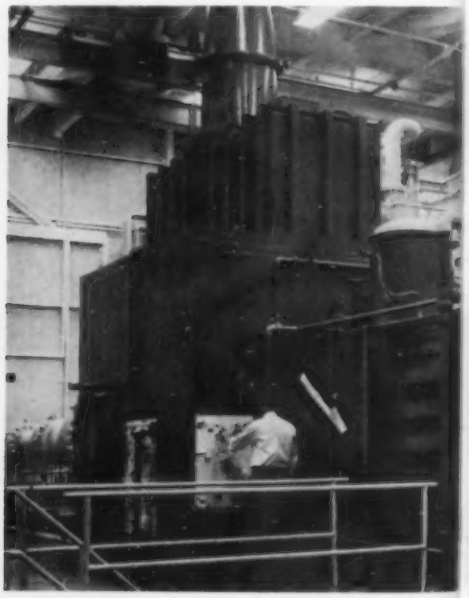
The installation is 120 ft. long, ending at a 70-ft.-high exhaust stack. From intake to exhaust, the tunnel incorporates many features of advanced engineering.

Skybolt and *Saturn* models are scheduled to follow the initial tests on the *Nike-Zeus* configuration. The "two-foot" diameter wind tunnel can handle models up to 36 in. long and 6 in. in diameter.

Air is supplied to the tunnel by a non-lubricated, carbon ring compressor, the only one of its kind owned by private industry. The only other compressor like it in the United States is located at NASA's Ames Laboratory.

Water is used to cool portions of the wind tunnel which are subjected to heating effects. The tunnel was designed by Douglas and Sandberg-Serrell Corp. of Pasadena. ¤





LEFT: *Test chamber is surprisingly large. Support strut mechanics permit tunnel operator to pitch test model up to 30° angle of attack and to roll it 200° while in hypersonic flow. Directly opposite large pressure-proof windows are used for optical observation of flow by shadow and other photography. Mass flow rate through free-jet test section at 2500 psia varies from 30-70-lb./sec.* **RIGHT:** *After completing mission, hypersonic stream enters "jet catcher" that directs it into variable-geometry diffuser within which kinetic energy of air stream is converted to pressure. Flow from diffuser spills into ejector plenum chamber leading to five air-driven ejectors, one 54-in. and four 30-in.-diameter jet pumps that pull 200 to 400 lb./sec. of flow through the ejector nozzles of room-temperature at 90 psig, regulated down from 525-psi, 26,500-cu.-ft. storage tank for adjacent supersonic tunnel. For Mach 10 tunnel pressure ratio, ejectors are operated to bring plenum down around 1 to 6 psia.*

ABMA Adds Vertical Test Ability

Huge new tower, other facilities, give Army what it needs to run virtually any static test of Jupiter-size birds

THE ARMY recently unveiled its new $8.4-million vertical test facility at Redstone Arsenal, Huntsville, Ala.

The facility, built for the Army Ballistic Missile Agency's Test, Evaluation and Firing Laboratory, is equipped to enable Army missilemen to conduct almost every conceivable type of test, short of actual flight, for missiles up to the size of a *Jupiter* IRBM.

Most imposing structure is a vertical test stand which features a climatic chamber capable of producing temperatures from −85 to +185°F.

In addition to the test stand, with its twin test positions, the 540-acre test area has an instrumentation and control building, two missile assembly and checkout buildings, environmental test building, attitude test stand, and several other office and engineering buildings. An independent water supply is installed for cooling the flame deflector of the test stand and for fire protection.

The large test stand rises 88 feet high from the base of its heavily-reinforced concrete blast pit to the top of its superstructure. Twin missile mounts on the stand enable engineers to mount two complete missiles—or, in the case of two-stage missiles, the first and second stages—side by side to perform simultaneous or sequential tests. With this capability, a missile's in-flight firing sequence can be tested, studied and evaluated.

The climatic chamber on the test stand allows engineers to precondition a missile and maintain that condition after putting the missile in a vertical position for firing. Prior to firing the motor, the huge door that forms the floor of the climatic chamber is automatically rolled away to clear the way for the motor's blast.

ABMA plans to incorporate a high-altitude simulator on the test stand at a later date. This will make it possible to static-fire missiles on the stand at simulated altitudes of 70,000 to 80,000 feet.

Motor exhaust gases will be channeled away from the test stand by deflectors located below the motor exhaust nozzle. Approximately 16,000 gallons of water per minute will be passed over the deflector during tests to cool it and protect it from the high exhaust temperatures.

W. L. GRAFTON, director of ABMA's Test, Evaluation, and Firing Laboratory, stands in front of Redstone's new 88-ft.-high vertical test stand.

During operations, data from measurement points on the missile under test will be carried by cables to strip-chart recorders, oscillographs, magnetic tapes and analog-to-digital data acquisition systems in the measuring center.

The analog-to-digital systems accept separate and distinct signals from 200 points on a missile at a rate of 10,000 signals per second. Banks of automatic electric typewriters type out data received by the systems.

In addition to the acquisition center, the blockhouse contains an engineering area and firing controls. Slit windows permit full viewing of the test stand from the console panels which control the tests.

The environmental building, located in a valley one-half mile from the test stand, can also provide temperatures from −85 to +185°F.

This building—50 ft. long, 40 ft. wide and 14 ft. high—can be used as a unit or divided into halves or quarters, depending on test requirements. Each quarter of the building has its own temperature unit and controls.

A complete *Pershing* missile and its ground support equipment could be placed in the building and tested simultaneously. ⌗

An Interplanetary Space Simulator

Four-million-dollar facility being built for JPL will be used to test Mariner A and other future spacecraft

JET Propulsion Laboratory is building a $4 million space simulator which will be used to test the ultimate design of interplanetary spacecraft.

With construction expected to be completed by the end of the year, the first spacecraft tested in the chamber will be the *Mariner A*, a half-ton Venus probe that stands 8 ft. high and measures 19 ft. across with solar panels extended.

The space environment simulator is being built for JPL by a team of industrial firms headed by Consolidated Vacuum Corp. of Rochester, N.Y.

The facility consists of a 10,000 sq. ft. building to house offices, a control room, an equipment area, and the space simulator. The latter is to be a cylindrical tower 80 ft. high and 27 ft. in diameter. Within the lower part of this silo-like structure, there will be a stainless steel vacuum chamber that measures 47 ft. high by 25 ft. in diameter for testing spacecraft. The upper part of the tower houses a solar simulator unit.

The new simulator is being designed to recreate the conditions that a spacecraft will endure during a three-month space flight to the nearest planets.

It will have an intricate optical system designed by Bausch & Lomb. Artificial sunlight will be generated by 150 compact arc mercury-xenon lamps. Each lamp utilizes 2½ kilowatts of power and has a 16-inch reflector.

Light from the mercury lamps will shine downward on a parabolic mirror and reflect upward in a concentrated beam to a hyperbolic mirror. From there it is reflected downward again through the lens and into the vacuum chamber.

Once inside the chamber, the 3-ft. beam of light has to be widened to 15 ft. To accomplish this, a special 2½-ft.-diameter mirror reflects the light beam to a parabolic mirror at the top of the cylindrical chamber. From there it shines down on the spacecraft in a collimated beam, as would sunlight in space. It is expected that the system will be modified to project a 25-ft. beam.

To create a vacuum condition, a three-stage "pump down" will be utilized. The first stage will be accomplished by seven compressors ordinarily used to run JPL's 20-in. supersonic wind tunnel. Then, as this line is valved off, a "roughing system," consisting of three vacuum blowers, removes all but a small fraction of the initial air. At this point, ten oil diffusion pumps take over to produce a vacuum 10^{-6} millimeters of mercury, which is about one billionth of the atmosphere at sea level.

In order to simulate the space environment, an aluminum shroud is being built inside the JPL chamber. The shroud is made of 200 plates which are dull black to absorb heat and cooled to −310°F. This temperature is maintained by pumping liquid nitrogen through small tubes running through the shroud. With this system, 99% of the heat radiated from the spacecraft is absorbed and carried away.

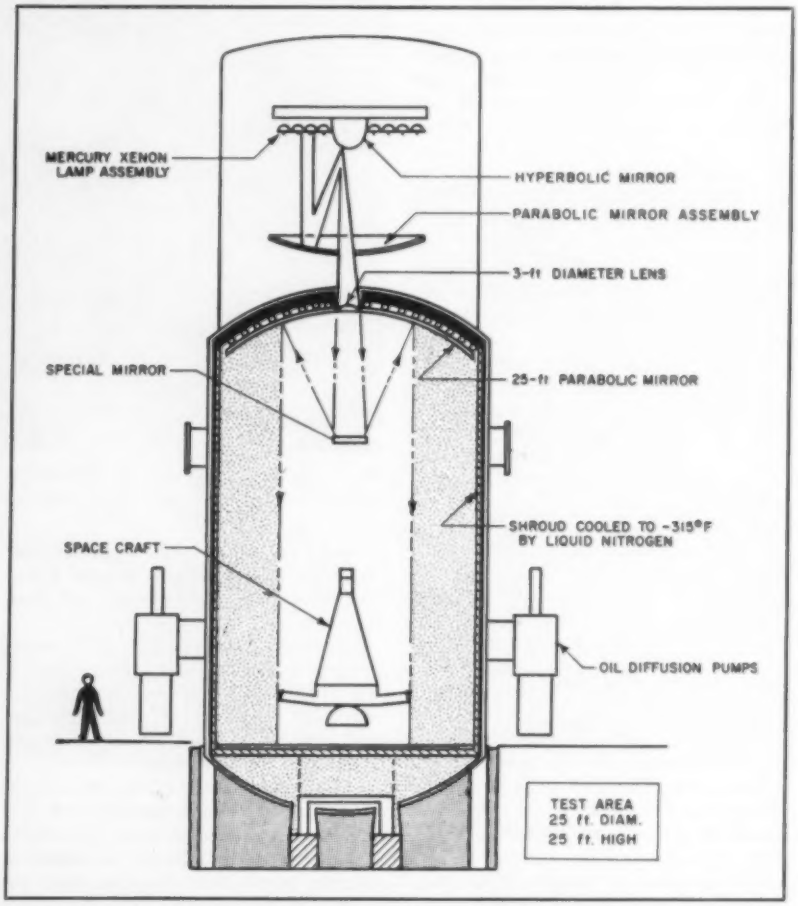
Consolidated Vacuum Corp.'s design and fabrication team includes the following subcontractors:

Pittsburgh-Des Moines Steel Corp., Pittsburgh, Pa.—Fabrication of the steel vacuum chamber and erection and assembly of the entire facility.

Aetron Division of Aerojet-General Corp., Covina, Calif.—design of the building, instrumentation and external cryogenics.

Bausch & Lomb,—design of the solar simulation system.

Tenny Engineering Corp., Union, N.J.—power system for lights. ⌘



SPACE ENVIRONMENT SIMULATOR consists of lighting system, vacuum chamber, and liquid-nitrogen-cooled shroud to simulate conditions of outer space.

Spark Ignition

(Continued from page 25)

liquid fuels—it will spark even when immersed in fluids such as insulating oil or water.

Sparking in a vacuum or under pressure results in uniform operation under widely varying conditions. With this type of system, high spark energies are easily obtained and exciters are quite simple. The storage life of an ignition system is quite long and the storage temperature in general is not critical.

The spark ignition system can be left energized for a long time, if necessary, as compared to a pyrotechnic device. Or it can be energized for a short period. The shorter duty cycle will result in a smaller system. But the system can be cycled many times. By slight changes, wide ranges of spark rates and energies can be achieved. Sparks with energies of 10 joules are easily obtained.

The duration of the spark is in the range of ten microseconds. A stored energy of one joule dissipated in ten microseconds would give an average energy level of 100,000 watts for that time. The material in the gap region remains as ionized, incandescent vapor for a considerably longer period.

Spark rates of 800 to 1200 sparks per second have been achieved, and higher rates are believed possible. In most cases, the high energies and spark rates mentioned will not be necessary. The high-rate system could be used to replace the glow-plug or hot-spot ignition system. Spark rates of 800 to 1200 sparks per second would appear to be a continuous hot spot like a glow wire and would be considerably hotter. The relatively high energies used in the glow wire could be duplicated by a high-spark-rate system. The main limitation of the glow plug is the long warm-up time (several seconds), whereas in the spark ignition system the time lag would be a few milliseconds and is predictable.

• **Radio filters needed**—One possible problem with the spark ignition system could be generation of radio interference. Radio interference filters can effectively eliminate any interference which would be conducted through the power lines. Radiated interference can be eliminated by adequate shielding of the igniter, exciter, and cable. In general, the system will be energized for only a few seconds during starting of the engine, making some degree of interference tolerable.

The power required for operation of the system would depend upon the required spark rate and spark energy. The normal input requirement would be between 50 and 500 watts. The system could be powered by either 28 volt d-c or 115 volt, 400 cycle alternating current. If a d-c input is used, an interrupter such as a vibrator or switching transistor is necessary to convert the d-c to a-c.

One limitation of the creepage gap system is its short life, as compared with the high-tension system. The life is sufficient for several hundred cycles, which would allow the most complex flight to be completed and still permit testing before actual use.

In the creepage-gap plug, the semiconductor between the electrodes results in a low resistance path between the centerwire and ground, making it impossible for a static electricity charge to build up on the wire. These igniters cannot be initiated by stray electromagnetic radiation.

The spectre of spark ignition systems has been their size. The igniters sometimes caused weakening of the motor structure by the necessarily large clearance holes. Many design changes and improvements in igniters have considerably reduced their size, while maintaining reliabilty.

Function checkouts of the ignition system during a countdown are usually required. There are available igniters which detect the occurrence of sparks.

An electrical signal is produced which can be fed into a counter or a go, no-go indicator to indicate the proper operation of the ignition system. This igniter is coupled with a system which senses an output signal from the igniter and determines the spark rate and spark energy; if they are above some minimum value, it will produce a go signal.

• **Telemetered spark**—The primary feature of this system is in determining the actual occurrence of the spark at the gap. This device could be used during the countdown to check out the complete ignition system and could be used at firing as a safety device—in that the fuel control valves could not be opened until a "go" signal was received from the ignition system. A system of this type could be used in other stages and could telemeter information back to earth on the operation of the ignition system.

If a shot failed, the spark monitor system would help to pinpoint the cause—whether it were the ignition system, fuel control system, etc.

Perhaps the ultimate in spark ignition systems is the integral igniter. This device is a complete ignition system in a single package. The igniter and exciter are combined in a single unit and the interconnecting cable is eliminated. The weight of this system is less than 0.75 lbs.

Units have been subjected to ambient soak temperatures of −110° to 250°F and ambient operating temperatures of −110° to 200°F with wider limits possible. The a-c input units are less affected by temperature than the d-c input units because of the transistors used in the latter.

The integral igniters contain no moving mechanical parts or fragile glass components. Silicon rectifiers are used in place of glass rectifiers. The discharge tube is a strong ceramic tube. On d-c input units, switching transistors are used instead of vibrators. For temperatures below 165°F, germanium transistors are employed, while applications above this temperature involve silicon transistors.

In a recent test, an integral igniter was placed in a vacuum chamber and tested at various vacuums simulating altitudes exceeding 100 miles. The unit was maintained at this condition for five hours and operated properly at all conditions. The lowest pressure reached was 0.07 microns of mercury absolute. This test disproves statements that spark ignition cannot be used in a vacuum.

The integral igniter can be built with an internal heat barrier to protect the electronic components from the high temperatures in the gap region. One model igniter can withstand 900°F at the igniter seat for four minutes with a 165°F ambient temperature. This heat barrier is necessary in multiple-start systems and adds about one inch to the overall length of the igniter. For single-start systems the heat barrier is left out; the result is a smaller, lighter unit. This version can, of course, be tested many times, but it will withstand only a single hot firing.

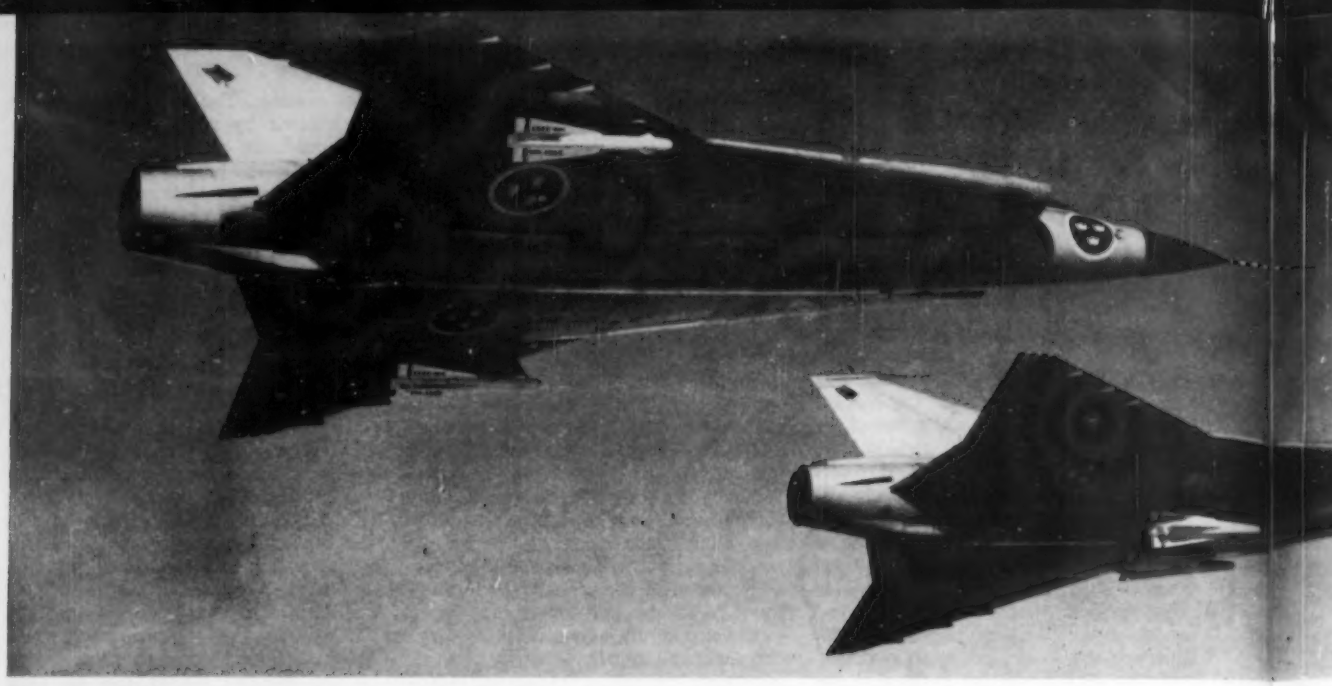
The use of spark ignition in liquid-fuel engines will probably increase. Igniters will become more reliable and will decrease in size. Exciters will decrease in size and weight, and will become capable of operating over temperature variations of −300°F to 600°F as high and low temperature components become available. In addition, exciters will be able to withstand extreme mechanical shock and vibration. Ignition systems in general will be more reliable, and provide higher energy outputs. Spark ignition may also have limited use in solid-fuel engines. ¤

British Weather Rocket Approaches Testing Stage

BRISTOL-AEROJET LTD.'s answer to *Arcas* will soon begin static testing.

The as-yet-unnamed low-cost high-altitude meteorological rocket is designed to carry an instrument pack to a height of 200,000 ft. After separation, the pack will descend by parachute.

The rocket's launch system consists basically of a 32-ft.-long tube, 24 in. in diameter, supported on a hinge and raised by a hydraulic strut. ¤



international

Sweden Adds Missile Punch on Land,

by Bernard Poirier

BOFORS AND SAAB have introduced five new missiles into Sweden's arsenal. They include an improved *Bantam* antitank version, the *Erika* ship-to-underwater ASW missile, and three versions of Hughes *Falcons* with infrared-homing and radar guidance.

Following year-long negotiations, the latest SAAB Draken fighter can now carry air-to-air and air-to-surface *Falcons*. New radome electronics and fire control to support this sophisticated armament are believed to be based on a Ferranti Airpass IIC design and manufactured in Sweden.

The improved *Bantam* is undergoing evaluation trials and has a new "stepped-fin" design with higher performance. If trials prove successful, MISSILES AND ROCKETS was told, the weapon will go into series production before the end of the year. This would cap Bofors' gamble on a private venture into missile system design.

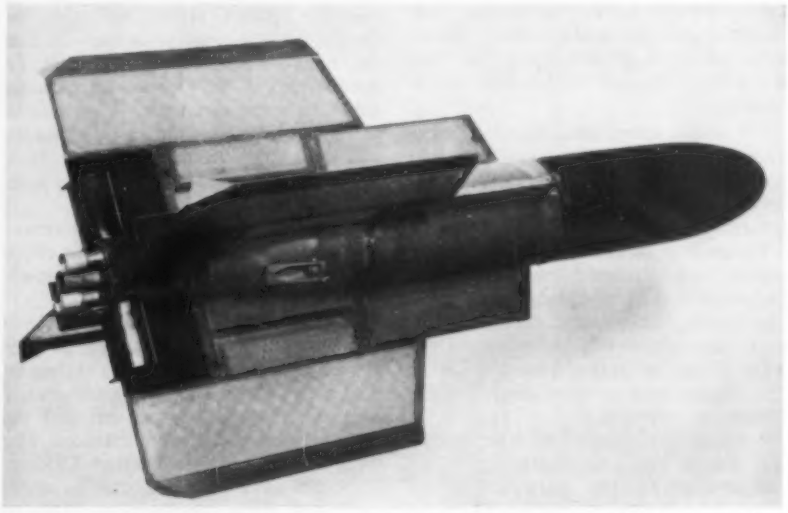
The *Erika*, also a Bofors offering, is a solid-fuel antisubmarine weapon which can be fired in salvos with 50-to-60-sec. intervals between rounds. Adjusting the azimuth for each unit rapid-fired from a 16,300-lb. four-barrelled launcher reportedly minimizes dispersion of the 220-lb. warheads.

The 6.5-ft. *Erika* has an all-up weight of 550 lbs. and a range over one mile for detonation by a mechanical fuze at 27 fathoms. Swedish sources say a new proximity fuze will be tried during the next scheduled sea trials.

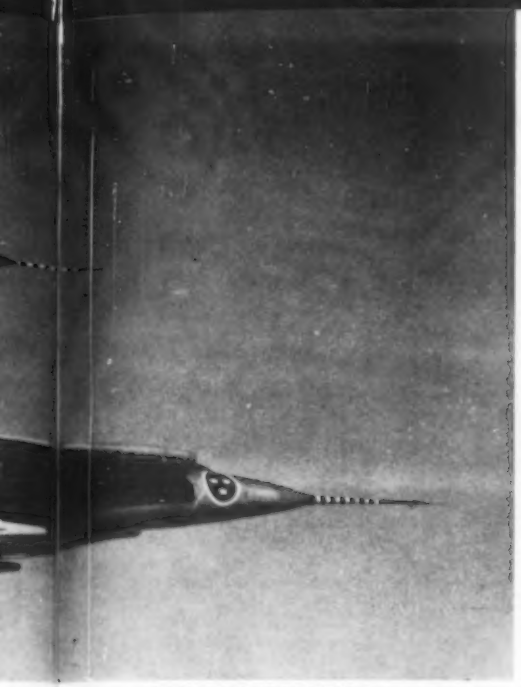
Sweden's Forsvarsstaben agency announced last November that it was studying and negotiating for Mach 2 *Falcons* with ranges around 5 miles. Versions believed to be included in the Hughes export deal are the *GAR-3A*, *GAR-4A* and the *GAR-11*. Versions weighing over 220 lbs. are mounted at three points below the Draken fuselage, or one each can be mounted on a wing. There can be as many as seven mounting points for lighter *Falcon* versions.

One of the main features of the advanced missile fire control built into the SAAB 35 Draken is the Pilot's Attack Sight (P.A.S.) located at eye-level in the cockpit. It can be coupled to a lock-on radar which searches or can be hand-controlled. (M/R, Jan. 9, p. 37).

• **Bantam details**—The new, 2.7-ft. wire-guided and gyro-stabilized *Bantam* with 15.7 in. fins has a 6600-yd. range



NEW BANTAM DESIGN is here revealed by Bofors AB for the first time. The former, experimental Bantam did not have this stepped-fin configuration.



NEW SAAB DRAKEN fighters can carry air-to-air or air-to-surface Falcons.

Sea and Air

and a firing weight of 13.2 lbs. It has an 8.8-lb. missile container and a 4.4-lb. control unit. In recent tests the weapon penetrated 16-in. armour and operated between −40°F and +140°F.

The aft wing corners are bent to make the missile roll in flight. When packed in the container the wings are folded against springs. The material of the airframe is largely laminated fiberglass-reinforced plastic.

Normally the *Bantam* has a hollow-charge warhead. This can easily be exchanged, however, if the mission requires it. The missile body contains the battery, guide-wire spools, transistorized signal receiver, powder-energized gyro and tracers.

The gyro starts when the missile is fired by electrical ignition of a powder charge. The electrolyte container bursts when ignition occurs and immediately activates the gyro wet-cell battery. This method gives the battery an unlimited storage life. Use of gyro stabilization indicates that the missile has some self-control enabling it to level off for quick recovery following initial thrust.

The *Bantam's* tracers help the gunner follow the 190-mph flight towards the selected target. Bofors says the new *Bantam* has the accuracy to kill tanks in one shot, and that several missiles can be set up on a vehicle or on the ground. Operation still is coordinated by one control unit, but with a special set of cables and a selector box. ⌗

soviet affairs

By Dr. ALBERT PARRY

Red rocket experts were afraid

last December that their failure to bring back from its orbit *Spacecraft III*, with dogs Pchelka and Mushka and other, smaller animals aboard, "would leave an unfortunate impression" on Major Yuri Gagarin and his fellow officers then in training for space flights.

This is revealed by Gagarin in *Pravda* for June 7. "However," Gagarin reminisces, "we understood that this was not inevitable, but only an accident; that life is far more complex than you suppose it to be. We were sorry about the loss of that satellite, in which such great funds had been invested. But in such a grandiose business, extra expenditures are unavoidable."

Nevertheless, several paragraphs later, returning to the loss of the rocket launched on Dec. 1, Gagarin speaks of "the somewhat bitter sediment, left by the loss of Pchelka and Mushka, the feeling which we feared to confess to ourselves, but which existed just the same." He assures the Soviet reader that this "sediment disappeared completely" in subsequent months, when the trainees heard about other, more successful Russian launchings, particularly the firing of the piggy-back rocket to Venus.

Daphne plants as astronauts' food

are discussed by Professor P. K. Isakov in a recent article, "The Era of Space Flights," in the Moscow *Trud*. He specifies the daphne plant growing in ponds and "feeding on algae," and writes of "recently published researches" conducted on this plant as a possible mainstay of the menu for long space flights. "They multiply quickly . . . they contain all the necessary nutritional values: albumens, fats, carbohydrates, mineral elements, and vitamins." Professor Isakov, a candidate of the biological sciences, is chairman of the Soviet State Committee on Cosmic Medicine and a Stalin Prize winner.

Rocket fuel successes

of the Soviets can be attributed to Professor Nicholas N. Semyonov "and his team," according to an article by N. Riazantsev in *Novoye Russkoye Slovo*, a New York Russian (anti-Soviet) daily. The émigré declares that Semyonov and his collaborators "brilliantly resolved this problem which still has not found its final solution among Western specialists"; it was Semyonov and his men who produced the fuel responsible for greater rocket thrust than America and her allies have so far achieved. (Professor Semyonov, winner of a 1958 Nobel Prize in physical chemistry, is known for evolving and explaining a complete and consistent theory of explosions and combustions, most of his basic work dating back to the 1920's.)

Auschwitz as a rocket-fuel base

is mentioned in *Izvestia* of May 31. In his article "Triumph of Life," A. Plyushch relates that among the Nazi war factories surrounding the mass-death camp of Auschwitz one giant "combinat" produced fuel for the *V-2* rocket through much of World War II.

Following the Nazi defeat, the Polish government under Soviet guidance restored the chemical factory. Some 240 Polish chemists and technicians were sent to the Soviet Union "to raise their qualifications" in Russian technicums and universities. They are back now in the former rocket-fuel "combinat," where phenol, synthetic rubber, and liquid oxygen are now produced, among a total list of 86 chemicals and plastics.

A national Space Age museum

and planetarium, dedicated to the memory of Konstantin E. Tsiolkovsky, will soon be erected in Kaluga, central Russia, near the park which bears the name of the pioneer rocket-man and contains his grave. A nationwide design contest was won by a team of Moscow architects headed by B. Barkhin.

contracts

NASA

$1,227,138—Chrysler Corp.'s Missile Div., Huntsville, Ala. and Detroit, for qualification and reliability testing on various engine, hydraulic, mechanical and structural components of the *Saturn* booster.

$589,000—Pratt & Whitney's Connecticut Aircraft and Nuclear Engine Laboratory, Middletown, for construction of a test stand for development of space radiators and condensers at Lewis Research Center.

$164,000—Inscho's Mechanical Contracts, Birmingham, Ala., from Marshall SFC, for expansion of water system that supplies test tower on which *Saturn* booster is static-fired.

$132,226—Bechtel Corp., Vernon, Calif., for development of design criteria of facility for static-testing the J-2 liquid hydrogen-liquid oxygen engine to be used to power the S-II stage of advanced version of *Saturn*.

$102,000—Micro Gee Products, Inc., Culver City, Calif., for specialized testing equipment for missile and spacecraft guidance systems.

$80,000—North American Aviation, Downey, Calif., for 2 *Little Joe* airframes.

$61,200—Whitmore Electric Co., Miami, for construction of electric duct work for the second *Saturn* complex, Cape Canaveral.

$54,000—General Dynamics/Convair, San Diego, Calif., for establishment of design concepts for "meteoroid bumpers" for protection of space vehicles in collision with meteoroids.

Telecomputing Corp., Los Angeles, from **General Electric,** for precision angle measuring instruments for the Orbiting Astronomical Observatory *(OAO)*. No amount disclosed.

DEPT. OF DEFENSE

$7,008,165—Raytheon Co., Lexington, Mass., for feasibility study of a new concept for ballistic missile defense (ARPAT).

MISCELLANEOUS

$3,275,000—Massachusetts Institute of Technology, Cambridge, from Advanced Research Projects Agency, for materials research.

$408,750—Electronic Associates, Long Branch, N.J., from **General Electric's Missile and Space Vehicle Co.,** for 3 heat-transfer general-purpose analog computers.

$68,000—Rocket Power, Inc., Mesa, Ariz., from **Sandia Corp.,** Albuquerque, N.M., for *Gila III* solid-propellant sled rockets.

NAVY

$1,217,396—Remington Rand Univac Div. of Sperry Rand, St. Paul, Minn., for continuation of studies and applied research leading to design of an ultra-high-speed data processing system.

$853,300—Consolidated Welding and Engineering Co., Chicago, for bow sonar domes.

$350,142—Arma Div., American Bosch Arma Corp., Garden City, N.Y., for miniature gyro compass equipment.

$247,670—Radio Corporation of America, RCA Laboratories, Princeton, N.J., for studies directed toward development of thermoelectric materials, fabrication and thermoelectric generator design for conversion to electric power by thermoelectric means.

$221,128—Project Fabrication Corp., College Point, N.Y., for engineering services and transportation for liquid oxygen, liquid nitrogen plant.

$130,977—Telectro-Mek, Inc., Fort Wayne, Ind., for design, development, and fabrication of 2 gross-thrust computers.

$61,676—Lasko Metal Products, Inc., W. Chester, Pa., for unassembled components of *Sidewinder* guidance and control containers, rocket motor containers and warhead containers.

ARMY

$34,580,102—Sperry Rand Corp., New York City, for production of *Sergeant* missile and related ground support equipment; research on the *Sergeant* missile system; and a classified contract. (Four contracts.)

$7,787,000—Martin Co., Baltimore, for hardware and development of *Pershing* ballistic missile system. (Two contracts.)

$6,221,230—General Dynamics/Pomona, Calif., for continued R&D on *Mauler* weapon system.

$5,913,177—Raytheon Co., Waltham, Mass., for concurrent and replenishment repair parts for *Hawk* missile. (Two contracts.)

$4,964,937—Raytheon Co., Waltham, for procurement of radar and production of radar test equipment for the *Hawk* missile system. (Two contracts.)

$4,435,032—Western Electric, Burlington and Winston-Salem, N.C., for production of ground guidance and control equipment for *Nike-Hercules*.

$3,196,278—Fruehauf Trailers' Missile Products Div., Los Angeles, for trailers and enclosures for the *Sergeant* missile system.

$2,062,326—Thiokol Chemical Corp., Bristol, Pa., for production of rocket and missile motors at Longhorn Ordnance Works, Marshall, Tex.

$1,150,000—Western Electric Co., New York City, for further development of the *Nike-Zeus* antimissile missile system.

$1,211,453—Aerojet-General Corp., Covina, Calif., for fabrication, installation and checkout instrumentation for a solid-propellant rocket motor test facility at Redstone Arsenal.

$1,093,859—Yuba Mfg. Div. of Yuba Consolidated Industries, Benicia, Calif., for blast valves and blast dampers for *Titan II* missile launch facilities.

$506,000—Radiation, Inc., Melbourne, Fla., for development of a digital data system for use with an experimental prototype of the *Nike-Zeus* defense center.

$471,500—Avco Corp., Everett, Mass., for research in re-entry physics.

$299,772—Universal Match Corp., St. Louis, for *Pershing* Erector Launcher Guided Missile Transportable (TEL).

$200,000—Dresser Electronics, SIE Div., Houston, from **Martin/Orlando,** for telemetry signal conditioning equipment in the *Pershing* missile program.

$162,141—Philco Corp., Lansdale, Pa., for production engineering measure to develop automatic production equipment for manufacture of silicon-surface alloy transistors (SAT).

$87,193—Applied Design Co., Tonawanda, N.Y., for design, development, and fabrication of 2 prototype containers for *Sergeant* body assembly and 2 prototype containers for *Sergeant* rocket motor, including technical data and final summary report.

AIR FORCE

$87,700,000—Pan American World Airways, for operation and maintenance of the Atlantic Missile Range.

$14,500,000—Paul Hardeman Co., Los Angeles, for production of propellant loading systems for the *Titan* ICBM.

$5,683,345—Douglas Aircraft Co., Santa Monica, Calif., for components, ground support equipment, spare parts, and engineering and technical data for the *Genie* rocket.

$3,000,000—Budd Electronics, Div. of The Budd Co., Inc., Philadelphia, for modification of NORAD gap-filler radars in the Semi-Automatic Ground Environment System (SAGE).

$2,500,000—General Dynamics Astronautics, San Diego, Calif., for 3 *Atlas* missile procedure trainers.

$1,500,000—Bendix Radio Div., Baltimore, for 6 AN/GPA-27A radar set groups; 2 AN/GPS-57A radar set groups.

$1,000,000—Itek Laboratories, Lexington, Mass., for research and study of what will happen to large, highly precise optical systems when hurled into space.

$850,000—Page Communications Engineers, Inc., Washington, D.C., for engineering, furnishing and installing a transportable troposcatter link for the Atlantic Missile Range.

$737,363—Dynatronics, Inc., Orlando, Fla., for range safety officer's console and display systems, 2 ea., and telemetry PCM tape copy system. (Two contracts.)

$635,618—Reeves Instrument Corp., Garden City, N.J., for on-site and off-site depot level maintenance for the AN/MSQ-39 radar bomb scoring system.

$630,015—Collins Radio Co., Cedar Rapids, Iowa, for single sideband communications equipment for the Atlantic Missile Range.

$477,550—Motorola Military Electronics Div., Scottsdale, Ariz., from **Philco Corp.,** for precision satellite tracking equipment. (Two contracts.)

$345,048—Del Mar Engineering Laboratories, Los Angeles, for 13 target systems, external tow rockets and missile, Type A/A37U-6.

$300,000—Coleman Engineering Co., Los Angeles, from **Convair, Ft. Worth Div. of General Dynamics,** for continuation of testing of escape capsule of *B-58* bomber.

$202,488—Arnoux Corp., Los Angeles, for telemetry decontamination systems.

$196,845—Hughes Aircraft Co., Culver City, Calif., for analytical and experimental studies to develop ion engine ground testing techniques.

$114,422—Itek Laboratories, Div. of Itek Corp., Cambridge, Mass., for 15 frequency standards.

$106,762—Sperry Microwave Electronics Co., Div. of Sperry Rand, Clearwater, Fla., for radar beacon checkout system.

$100,000—General Electric's Defense Systems Dept., Syracuse, N.Y., for test equipment to support *Atlas* organic maintenance plan for FY '60; **$70,000—GE's Missile & Space Vehicle Co.,** Philadelphia, for initial MGE/OGE spares and depot overhaul spares for *Atlas* General Electric peculiar Mark IV re-entry vehicle subsystem.

$92,292—Milgo Electronic Corp., Miami, for data converters and Mod. IV sequencer.

Measurement Systems, Inc., So. Norwalk, Conn., for development of an infrared polar recording nephelometer. No amount disclosed.

names in the news

SHERMAN

SCHUTZ

PRESTON

SNOW

FELLING

Dr. Christopher Sherman: Experimental plasma physicist, joins Geophysics Corp. of America, Bedford, Mass., where he will conduct studies on novel systems for space vehicle propulsion. Dr. Sherman formerly was senior scientist for Avco Corp.'s Research and Advanced Development Division.

Lt. Gen. Clovis E. Byers, USA (Ret.): Named vice president-Washington, D.C., office for General Telephone & Electronics Corp., succeeding **Adm. Frederick J. Bell,** USN (Ret.) who will continue as a consultant.

Gerald C. Schutz: Formerly with Bendix Systems Division, named vice president-engineering and sales, Vitro Electronics, a division of Vitro Corp. of America.

Donald W. Bodene: Joins the Product Development Dept. of The Beryllium Corp., Reading, Pa. Formerly Bodene was chief metallurgist at Rolle Mfg. Corp., and metallurgical engineer at the Aluminum Co. of America.

Cledo Brunetti: Formerly with Grand Central Rocket Co., rejoins one of its parent companies, Food Machinery and Chemical Corp., as special assistant to the president. **John J. Crowley,** vice president and formerly assistant general manager, named acting general manager of GCR.

W. L. Young: Former manager of operations of Convair's Astronautics Division, joins Guidance Technology, Inc., Los Angeles, Calif., as director of manufacturing operations.

Dr. Howard L. Recht: Named chief of electrochemistry laboratory; **Dr. Richard E. Smith,** chief of solid state devices laboratory; and **Karl A. Sense,** research scientist in the energy conversion section of Astropower, Inc., Cost Mesa, Calif.

Benjamin F. Rose, Jr.: Manager of Aerojet-General Corp.'s AEtron Division, Covina, Calif., elected a vice president of the corporation.

Eugene F. Peterson: Elected vice president of marketing, consumer and industrial products of International Telephone and Telegraph Corp., New York City. Prior to joining IT&T, Peterson served in various executive capacities with General Electric Co. for 27 years.

Verser Gillon: Named manager of program planning for General Dynamics division at Fort Worth, Texas.

H. Holt Apgar: Named product supervisor at Vitro Chemical Co., a division of Vitro Corp. of America, New York City. Apgar formerly was with S. Wimpie Associates, Inc., and Sylvania-Corning Nuclear Corp.

William E. Roberts: Former executive vice president of Bell & Howell Co., named president and chief executive officer of Ampex Corp., Redwood City, Calif., succeeding **George I. Long, Jr.,** who will continue as a director.

Maj. Gen. Joseph J. Preston: Named commander of Strategic Air Command's 1st Missile Division, Vandenberg AFB, Calif. The General's previous assignment, as Commander of the 22nd Air Division with Headquarters at Malmstrom AFB, Mont., was to lay the groundwork for the ICBM *Minuteman* program. Gen. Preston replaces **Gen. David Wade,** who will take command of the Sixteenth Air Force with headquarters in Torrejon, Spain.

Neil M. Blair: President of RF Products Division of Amphenol-Borg Electronics Corp., named president of FXR Division. **Henry Feldmann,** chairman and president of FXR, Inc., before it was merged recently with Amphenol-Borg, will continue as chairman of the FXR Division.

E. Nevin Kather and **John T. Thompson:** Former division general managers, elected vice presidents of Raytheon Co., Lexington, Mass. **Kenneth M. Lord** elected vice president-manufacturing and purchasing; **Richard P. Axten** elected secretary.

E. J. Venaglia: Former manager of Sperry Rand's Microwave Electronics Co., appointed manager of Sperry's System Group program to convert two 11,000-ton troop carrier ships into mobile missile-tracking stations (MARS) for use on Atlantic Missile Range.

Mel Snow: Named manager of quality control for Pan American Airways' Guided Missile Range Division. Prior to joining Pan Am, Snow was procurement manager for Westinghouse Atomic, Pittsburgh, Pa.

James N. Waggoner, M.D.: Appointed aerospace medical director for The Garrett Corp., Los Angeles, Calif. Previously, Dr. Waggoner was medical director for Garrett's AiResearch Mfg. Division, and was one of nine elected a Fellow by the Aerospace Medical Association for his outstanding contribution to the aerospace medical field.

T. R. Hensley: Named plant engineer for Solid Propellant Operations, Rocketdyne Division of North American Aviation, Inc. at McGregor, Tex. Hensley replaces **W. J. Mundy,** who returns to the company's corporate offices in Los Angeles.

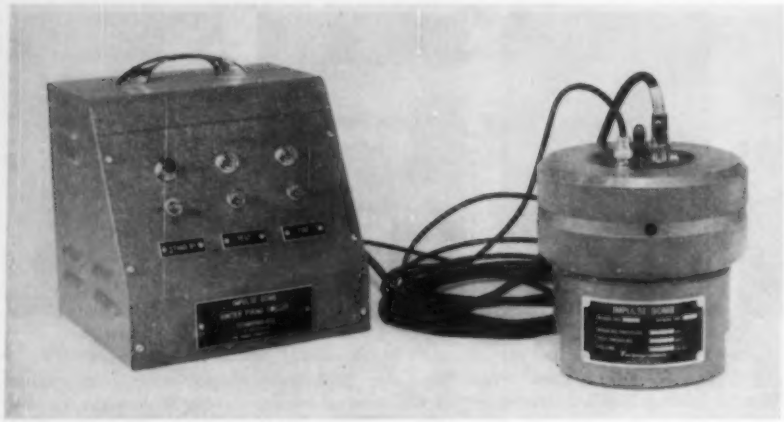
Warren R. Yuenger: Appointed research scientist by Ling-Altec Research Division of Ling-Temco Electronics, Inc., Anaheim, Calif. Before joining Ling-Altec Research, Yuenger was with Cubic Corp.

Dr. William E. Felling: Named director of scientific liaison-universities and professional societies for Raytheon Co., Lexington, Mass. Previously Dr. Felling was a research scientist for McDonnell Aircraft Corp.

Capt. Richard S. Garvey, USN: Named to head the Pacific Missile Range Safety Dept., Point Arguello, Calif., succeeding **Capt. W. P. Murphy,** USN, who will attend the Naval War College, Newport, R.I.

King H. Dendy: Former president of Microsecond Electronics, Inc., joins PCA Electronics, Inc., Hollywood, Calif., as vice president.

Dr. Garland M. Branch and **Roger J. Segalla:** Named consulting microwave physicist and radio frequency measurements specialist, respectively, in the research section of General Electric's Superpower Microwave Tube Laboratory, Schenectady, N.Y. Also named to the advanced engineering section of the Laboratory were: **Charles W. Belichner,** circuitry engineer; **Jerome J. Hamilton** and **W. John Pohl,** design engineers.



Propellant Impulse Bomb

Technoproducts Inc. is adding the Model 601 Impulse Bomb to its line of standardized test equipment for the rocket propellant industry. The Model 601 Impulse Bomb has a nominal volume of 5 cu. in., and is rated for a maximum working pressure of 30,000 psi. It was developed primarily for testing high-energy solid propellants and liquid monopropellants.

The Model 601 Impulse Bomb is supplied complete with pressure transducer and firing circuit. The only additional equipment required is a suitable recording system to receive the output of the transducer.

Circle No. 225 on Subscriber Service Card

Printed Circuit Mounts

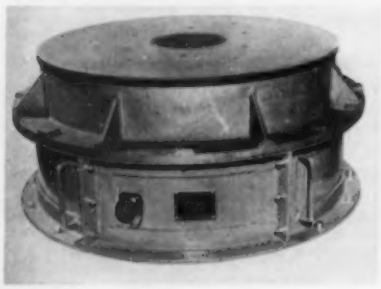
A clamp to shock-mount printed circuit cards is available from Moore Associates, Inc. The printed circuit cards are held firmly in place with the clamp, maintaining proper electrical and mechanical connection with the connector socket. The clamp is a metal strip, as long as the card, with a U-shaped notched retainer at one end.

Circle No. 226 on Subscriber Service Card

Antenna Pedestal

Antlab, Inc. has developed a versatile Azimuth Antenna Pedestal (Model 3606) so lightweight that it can be used at the top of a tower as well as at lower levels. The unit, weighing only 300 lbs., is designed so that a mast of up to 5½-in.-diameter may be installed through the vertical axis by the user. This auxiliary mast shares the over-turning load on the support-bearing from such ambient conditions as wind force and antenna weight. Compact in design and ruggedized for severest of atmospheric conditions, the pedestal develops a torque of 1000 ft./lbs. at 1½ rpm. The pedestal may be either servo-controlled or operated electro-manually.

Circle No. 227 on Subscriber Service Card



Liquid Interlock Switch

The Cat. 325 Liquid Flow Switch, specifically designed for use as a protective device to operate a switch when the flow of a fluid is a critical factor for operating efficiency, is available from Henry G. Dietz Co. Featuring low pressure drop, high current capacity, and immunity to shock and vibration, it employs no diaphragms or moving shaft seals.

Circle No. 228 on Subscriber Service Card

Coaxial Ferrite Isolator

A broad-band coaxial ferrite isolator featuring very high isolation-to-insertion characteristics is in production at Kearfott Division of General Precision, Inc. The model consists of coaxial construction with permanent magnet transverse field and ferrite sections built into the unit. The connectors used on the isolator are Type "N" female coaxial. These can be changed to fit customer requirements.

Circle No. 229 on Subscriber Service Card

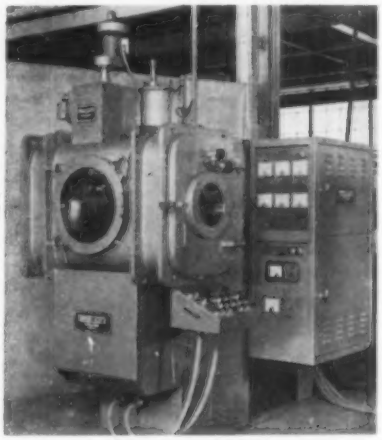
Hi-Strength Film Adhesive

A high-strength thermosetting film adhesive which can be cured at low pressures for metal-to-metal bonding and metal honeycomb sandwich construction is being marketed by Adhesives, Coatings and Sealers Division, Minnesota Mining and Manufacturing Co. Scotchweld Brand AF-110 can be cured under pressure in the range of 10 to 25 psi. The only pressure necessary is that required to provide contact between the parts being bonded and to keep the parts properly aligned. The adhesive exceeds the requirements of military specification MIL-A-5090D-Type 1 for metal-to-metal bonding and MIL-A-25463-Type 1, Class 2 for honeycomb sandwich construction.

Circle No. 230 on Subscriber Service Card

Electron Beam Welder

Sciaky Bros. Inc. is marketing a newly designed electron beam welder, Model VX-20-30-48. The vacuum chamber measures 20 in. wide x 30 in. high x 48 in. long. Complete gun mobility takes full advantage of the internal chamber dimensions. The electron gun is provided with traverse motion (Y axis) and vertical motion (Z axis) powered by Sciaky's speed and position servo-control. This control also effects longitudinal motion (X axis) to the internal work table. Numerical control is easily adapted to the Sciakydyne Control concept.



Circle No. 231 on Subscriber Service Card

Photoelectric Sensors

Solar sensors, designed for operation in a space environment, are being produced by Ball Brothers Research Corp. These photoelectric sensors are used primarily to provide high-performance servo control of rocket and satellite-

borne sun trackers. Solar sensors can be furnished with various angular characteristics for coarse servo control, fine servo control, spin detection and aspect determination. An EA-3 amplifier has been built to condition signals from the sensors for either telemetering or servo applications. The amplifier is a completely transistorized, low-drift device. As a single-ended amplifier, the output range is from 0 to 5 v for telemetering or 2.5 v +2.5 v for servo control.

Circle No. 232 on Subscriber Service Card

Hi-Temp Tape

A pressure-sensitive tape designed to reflect extreme heat from motors, wires and delicate structural parts is available from Minnesota Mining and Manufacturing Co. Called "Scotch" brand No. Y-9050 heat reflective tape, it is capable of performing continuously at temperatures of 500 to 600°F, and can withstand more than 3000°F of radiant heat for short periods.

Circle No. 233 on Subscriber Service Card

Radiotelescope Controller

A digital data system designed for the precise control of a radiotelescope is available from Datex Corp. The sys-

tem will check the actual position of the radiotelescope antenna against a required position recorded on tape and control antenna movement so that the antenna is precisely positioned to stay on the signal area. Except for a high-speed perforated tape reader, the system has been designed from standard Datex modular system components, including K-111 Control Chassis, DC-113 Digital Clock, and PC-104 Programer.

Circle No. 234 on Subscriber Service Card

Radiflo Leak Detector

A Type 24-510 Radiflo Leak Detector for high-efficiency production-line testing is available from Analytical & Control Division of Consolidated Electrodynamics Corp. Capable of testing hermetically sealed components for

leaks in the 10-11 atm cc/sec range, depending upon component size, it can test up to 10,000 transistors in a single activation cycle of less than an hour. Either GO-NO-GO or quantitative inspection can be performed on individual components with a scintillation counter which measures the radiation level. The presence of tracer gas is indicated on an auxiliary rate meter.

Circle No. 235 on Subscriber Service Card

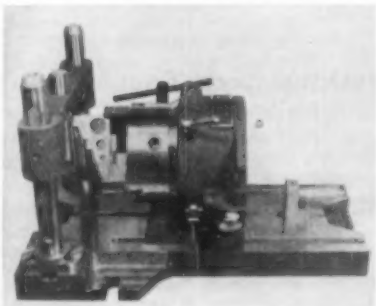
Temperature Chamber

Wyle Laboratories has designed a liquid CO_2-cooled miniature high-low temperature chamber, Model C-106, for use in environmental simulation tests of electronic, missile, and aerospace components. Temperature range is from −100°F to 500°F with an accuracy of control of ±0.5°F. Temperature is controlled by means of an electronic unit with resistance bulb sensor which "anticipates" on a proportioning basis the actual set-point, either high- or low-side, and effects minimum variation in temperature over the full range.

Circle No. 236 on Subscriber Service Card

Horizontal-Drilling Unit

A horizontal drilling and master spacer unit for rotary positioning work with great precision is available from Erickson Tool Co. The rugged multi-index spacer is teamed with a drilling device which can be set to Jo-block accuracy. The unit guarantees repeat indexing within low tenths—radial accuracy of 0.001 in. cumulative error on



a 6-in.-diameter circle. Location of holes being machined in relation to the part can be held to ±0.0005 in. or closer. The unit can be set up with a planer gage, micrometer, or gage blocks.

Circle No. 237 on Subscriber Service Card

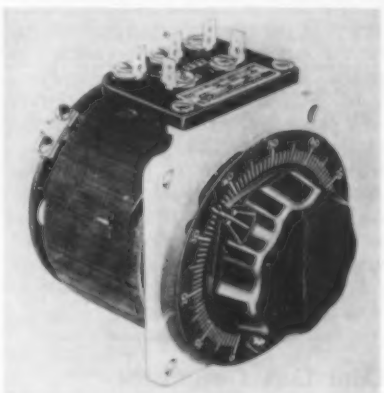
Ball Couplings

A new concept in ball-type self-sealing quick-disconnect couplings, providing "Boresite" smoothness throughout the entire flow passage, has been developed by General Pneumatics Corp. Exactly 90° rotation of the balls is accomplished by twisting the cover approximately one quarter turn, without resorting to gearing or cams. The use of rubber seals throughout the assembly provides zero external leakage in either the coupled or uncoupled conditions, even when the medium is a gas. The locking device is visible from all angles and, because it is an integral part of the rotating mechanism, is extremely rugged and positive.

Circle No. 238 on Subscriber Service Card

Variable Transformers

A compact 50/60 cycle Powerstat variable transformer series introduced by Superior Electric Co. has output ratings up to 3.75 amp with constant current loads and up to 5.5 amp with constant impedance loads. Called the 21

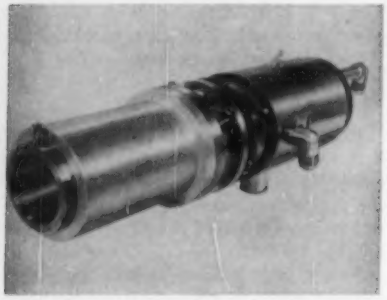


Series, the Powerstats include: gold alloy-plated commutator; functionally designed terminal arrangement for connection flexibility; terminal adapters for either soldered connections or push-on connectors; adjustable ⅜-in. solid metal shaft; square base design for increased strength and reduced overall height and space behind panel.

Circle No. 239 on Subscriber Service Card

Plasma Modular Mixers

Two modular mixing attachments for a 300KW arc plasma generator have been introduced by Plasmadyne Corp. The subsonic and supersonic mixing modules are used to create environments for re-entry testing of materials, heat transfer and gas dynamic evaluations



of high-temperature gases and plasmas and for chemical synthesis investigations, magnetohydrodynamics studies and plasma jet thrust investigations. The attachments are available in two configurations.

The AM-4 is designed to operate into ambient pressures between 0.5 and 2.0 atmospheres (abs.) and provides a subsonic plasma stream. The second unit, the AM-5 assembly, operates into a vacuum nominally 1/17th that of the associated M-4 mixing chamber and provides a supersonic flow, nominally Mach 2.5 in air.

Circle No. 240 on Subscriber Service Card

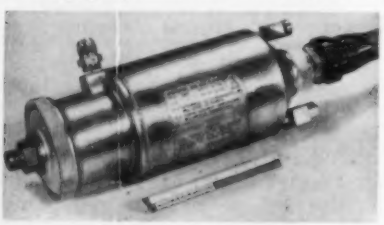
Floating Locknuts

The Delron Co. has avalable a complete line of structural floating locknuts for honeycomb- or sandwich-type panels. The Delron 700 series combines a floating nut element with a structural type panel fastener. The floating action of the fastener allows for total misalignment of 1/16 in. One straight-drilled thru-hole prepares the panel for fastener installation. Hand arbor press or any ram-type equipment can be used to expand the fastener within the core area, making it possible to distribute loads to both cover sheets.

Circle No. 241 on Subscriber Service Card

Cool Gas Generator

A cool gas generator with significant advantages over prior systems for the inflation of lightweight rubber/fabric bags is available from McCormick Selph Associates. The generator incorporates an electrical initiator, a solid propellant for gas generation and pressurization, and a coolant for temperature control. During operation, the hot gas from the burning propellant is mixed with the coolant within the gas generator. Upon mixing, vaporization of the coolant reduces the temperature of the hot propellant gas to a predetermined value, depending upon the ratio of hot gas to the coolant.

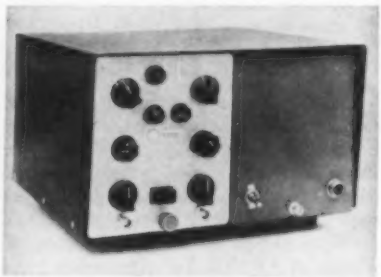


Circle No. 242 on Subscriber Service Card

Scope Display Test

A transistor test instrument that provides an oscilloscope display of beta (grounded emitter current gain) as a function of collector current has been developed by Orbitec Corp. Orbitec Model T3A-2 is capable of showing a complete plot of beta vs Ic from 0 to 500 ma peak current at fixed frequencies of 1 kc and 10 kc. Provision is also made for obtaining such plots out to 1 mc by means of an external generator.

The instrument provides a convenient method for checking the beta characteristics of transistors for use in linear or non-linear circuits where beta values



are important parameters of design. In addition, the instrument will be of value to transistor manufacturers who are seeking ways to improve production methods of selected transistors.

Circle No. 243 on Subscriber Service Card

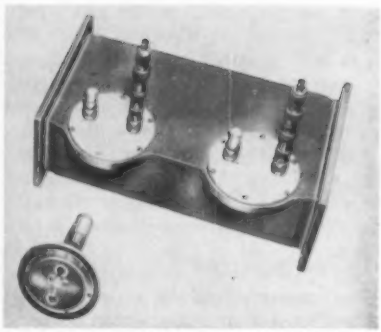
Mobile Computer

Clary Corp. is marketing a mobile DE-60 M computer. The four-wheeled unit consists of Clary's direct-entry transistorized DE-60, contained in a walnut cabinet, with input and output units recessed in top surface wells. The programing unit is located at the front and the arithmetic center is accessible from the rear. The unit is available with typewriter, punched tape or line printer output.

Circle No. 244 on Subscriber Service Card

Resistive Loop Coupler

A family of bi-directional resistive loop couplers is being marketed by FXR, a division of Amphenol-Borg Electronics Corp. These couplers feature high directivity and coupling attenuation in minimum space. The total length of the L band model, including the necessary WR-650 waveguide mounting section, is only 15 in. In-



tended primarily for power and VSWR monitoring, the S61-2 has been used in waveguides pressurized to 30 lbs., carrying 15 Kw average and 10 Megawatts peak power.

Circle No. 245 on Subscriber Service Card

Vacuum Block Valves

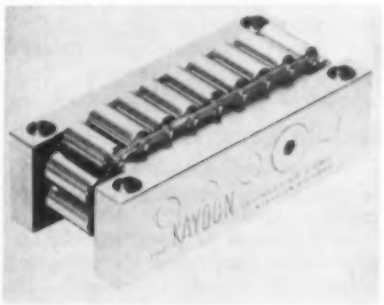
A series of block valves for mounting in various types of industrial high-vacuum systems, available from NRC Equipment Corp., have a common bellows seal assembly for sizes less than 1 in., are factory leak-tested and provide for maximum gas flow within compact design. Machined from solid-brass square stock, the porosity-free valves are available with in-line or angle configurations for soldered or screwed connections in sizes from ¼ to 1½ in.

Circle No. 246 on Subscriber Service Card

Low Friction Bearing

A recirculating roller bearing with the lowest and most uniform friction characteristics available is being produced by The Kaydon Engineering Corp. This Recirc-L-Way bearing has a coefficient of friction as low as 0.00025 under 500 lbs. load and 0.25 in./min. linear motion. With this load and speed, the bearing has only one-eighth of the coefficient of friction produced in other bearings of this type. Ultra-precision matched sets may be obtained with a total height variation within ±0.000010 in. Design concepts of the bearing include the use of a recirculating cage with positive roller guidance between lipped raceways.

Circle No. 247 on Subscriber Service Card



—reviews—

PROGRESS IN AERONAUTICAL SCIENCES, Vol. 1, edited by Antonio Ferri, D. Kuchemann, and L. H. G. Sterne, Pergamon Press Inc., New York, 280 pp., $12.

The theory of the current series of which this is the first volume is to publish an annual text of specially commissioned papers in the aeronautical sciences which "will provide the specialist reader with an orderly but concise survey of recent work. . . ." This is an admirable project but necessarily falls far short of its goal—if for no other reason than space considerations.

The field is somewhat limited by the admitted exclusion of papers on propulsion and combustion, and the articles presented cannot touch much of the major work being done in aeronautics. Nevertheless, the seven papers included are well presented and cover modern lines of research such as chemical reactions in boundary layers, hypersonic ablation, and the dynamics of an ionized gas.

BASICS OF ANALOG COMPUTERS, T. T. Truitt and A. E. Rogers, John F. Rider Inc., New York, 400 pp., $12.50.

An almost pictorial presentation, this book utilizes more than 400 diagrams and text in a quick and easy-to-understand introduction to analog computer theory. This publishing technique, typical of Rider, has proved quite successful, particularly in a companion volume—"Basics of Digital Computers."

The analog text is not recommended for computer engineers and scientists. It should be illuminating, however, to technicians in the field and to non-computer engineers interested in some light technical reading.

It is divided into three volumes—the first concerned with analog computing principles, the second with general-purpose analog computers, and the third with use of the d-c analog computer.

SPACE ASTROPHYSICS, edited by William Liller, McGraw-Hill Book Co., Inc., New York, 272 pp., $10.

Dedicated entirely to astronomical and astrophysical problems investigated from above the atmosphere, this book compiles the lectures given during the 1959-60 academic year at the University of Michigan's department of astronomy.

The contributors include many of the world's better-known workers in astrophysics. They give detailed descriptions of the astronomical experiments made with artificial satellites and space probes, and relate the theoretical investigations behind some of these experiments.

The book features much previously unpublished material and is a worthwhile addition to the library of any student of astrophysics.

—when and where—

JULY

Planning Aspects of Atomic Shelter, Seminar, Pennsylvania State University, University Park, July 9-12.

4th International Conference on Medical Electronics Combined with 14th Annual Conference on Electric Techniques in Medicine & Biology, Waldorf-Astoria, New York City, July 16-21.

Western Plant Maintenance and Engineering Show, Pan Pacific Auditorium, Los Angeles, July 18-20.

Structural Engineering Aspects of Atomic Shelter, Seminar, Pennsylvania State University, July 23-Aug. 4.

AFOSR, Differential Equations in Nonlinear Mechanics, Cosponsored with Martin's RIAS, Air Force Academy, Colorado Springs, July 31-Aug. 4.

Physics of the Solar System and Reentry Dynamics, National Science Foundation, NASA, Virginia Polytechnic Institute, Blacksburg, Va., July 31-Aug. 11.

AUGUST

Space Age Astronomy, sponsored by Douglas Aircraft Co., CalTech, Pasadena, Aug. 7-9.

American Rocket Society/Stanford University Guidance and Control Conference, Stanford University, Calif. (Some sessions classified), Aug. 7-9.

Society of Photographic Instrumentation Engineers, 6th Annual Technical Symposium, Ambassador Hotel, Los Angeles, Aug. 7-11.

Survival in the Nuclear Age-Executive Management Seminar, Pennsylvania State University, Aug. 13-18.

International Astronomical Union, 11th General Assembly, Pasadena, Calif., Aug. 15-24.

American Rocket Society International Conference on Hypersonics, Massachusetts Institute of Technology, Aug. 16-18.

National Naval Aviation Meeting, Institute of the Aerospace Sciences, San Diego, Calif., Aug. 19-24.

Welded Electronic Packaging Association Symposium, Lockheed Missiles and Space Division's Palo Alto Research Facility, Aug. 21.

National Academy of Sciences 10th Pacific Science Congress, University of Hawaii, Honolulu, Aug. 21-Sept. 8.

Western Electronics Show and Convention (WESCON), Cow Palace, San Francisco, Aug. 22-25.

American Rocket Society, 4th Biennial Gas Dynamics Symposium, cosponsored with Northwestern University, Technological Institute, Evanston, Ill., Aug. 23-25.

American Institute of Electrical Engineers, Pacific General Meeting, Salt Lake City, Aug. 23-25.

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editorial . . .

The Moment of Truth Is Here

A GREAT DEBATE is under way among the nation's defense experts in Congress, the military services and the Administration concerning the future of our missile and space programs. It has been gaining headway for the last several months, and the President's call for additional spending of $7-9 billion on space over the next five years has added impetus to it.

Like an iceberg, only a small fraction of this debate shows above the surface. But the portion which appears in the form of public statements and Congressional testimony is sufficient to indicate the depths to which it reaches.

This debate is to be expected in the early days of a new Administration and, if not permitted to continue too long, is a healthy thing. But it is apparent that the time has come to end the debate, make some clear policy decisions and begin developing the teamwork necessary to put this nation ahead of the Soviet Union in missile/space activities. Further infighting will only develop tensions which can slow the entire effort.

Let's take a look at some aspects of the debate, as they show on the public record—those portions of the iceberg above the surface, as it were. The aircraft vs. missile wrangle, once quiescent, is raging again:

May 3—"After all, the missile can do only one of two things; it can go or it cannot go. A bomber, on the other hand, has an almost infinite variety of capabilities."—Chairman Carl Vinson (D-Ga.), House Armed Services Committee.

May 12—"It has not been demonstrated that an intercontinental ballistic missile with a nuclear warhead will actually work."—Senate Armed Services Committee report.

May 26—Secretary of Defense McNamara stated that if Congress provided funds for additional manned bombers, he would recommend against spending the money.

June 28—The House provided $448 million in new obligational authority for long-range bombers.

July 2—Outgoing Air Force Chief of Staff Thomas White stressed the continuing importance of manned bombers before a nationwide TV audience, noting that the Russians have been flying what appears to be a new long-range bomber over Moscow in preparation for the Tushino air show.

We can remember when the Russians feinted us on this one before. Accepting phony intelligence of a rapid Soviet bomber buildup, we poured money into manned aircraft programs only to discover that the Russians actually had been putting their strongest efforts into missile development. We were far behind and today there is a well-publicized Missile Gap. Or is it that the Soviets now feel they must close the Bomber Gap? The Administration must decide.

We can find further evidence of the great debate in the *Dyna-Soar* program:

March 1—Gen. Schriever made it clear he would like a $100-million increase in Fiscal 1962 funding for *Dyna-Soar*—to bring the total to $170 million.

June 21—Assistant Secretary of Defense John Rubel expressed doubts that additional funding would substantially speed up the program and added: "*Dyna-Soar* is expanding at about the right rate."

June 26—Secretary McNamara questioned whether additional *Dyna-Soar* money could be used either effectively or efficiently.

June 28—In an effort to prod the Administration into a three-year speed-up, the House voted an additional $85 million for *Dyna-Soar* above the $106 million already in the Fiscal 1962 budget.

We might point out that, while not an accepted member of the debating teams, Yuri Gagarin told a press conference in Helsinki on July 3 that the next Soviet space flight will be more serious and informative than any U.S. space project.

THE DEBATE CONTINUES also over the need for U.S. military space programs:

June 21—Assistant Defense Secretary Rubel stated that the next decade will see only a modest use of space for military purposes, consisting largely of support functions such as *Samos, Midas* and the communications satellites. He added: "I doubt if there will be a military base on the moon (within the next 25 years). It may be more important in the next few months to have a few men in Laos than to have them in orbit."

June 27—"Earth can be dominated from space. . . . The lesson is clear that a vehicle in orbit which can launch a missile up and away toward Venus is not limited as to aiming points on the earth close below. We are determined not to be disfranchised in space, and we are determined that no nation shall be disfranchised on earth by a threat from space."—Air Force Secretary Zuckert.

June 28—Dr. H. Guyford Stever, chairman of NASA's research advisory committee, said putting a man on the moon is a military necessity for the U.S. Unless the Air Force wins a major role in the moon program, he said, "it stands to lose headway in development of future military space capabilities."

And so the debate continues. But it is now a time for decisions. The late Ernest Hemingway put into the common language a phrase well known to aficionados: the moment of truth.

For the Kennedy Administration, in this field, it is here.

William J. Coughlin

First privately owned and operated space-age plant furnishes liquid hydrogen to missile centers and industrial users

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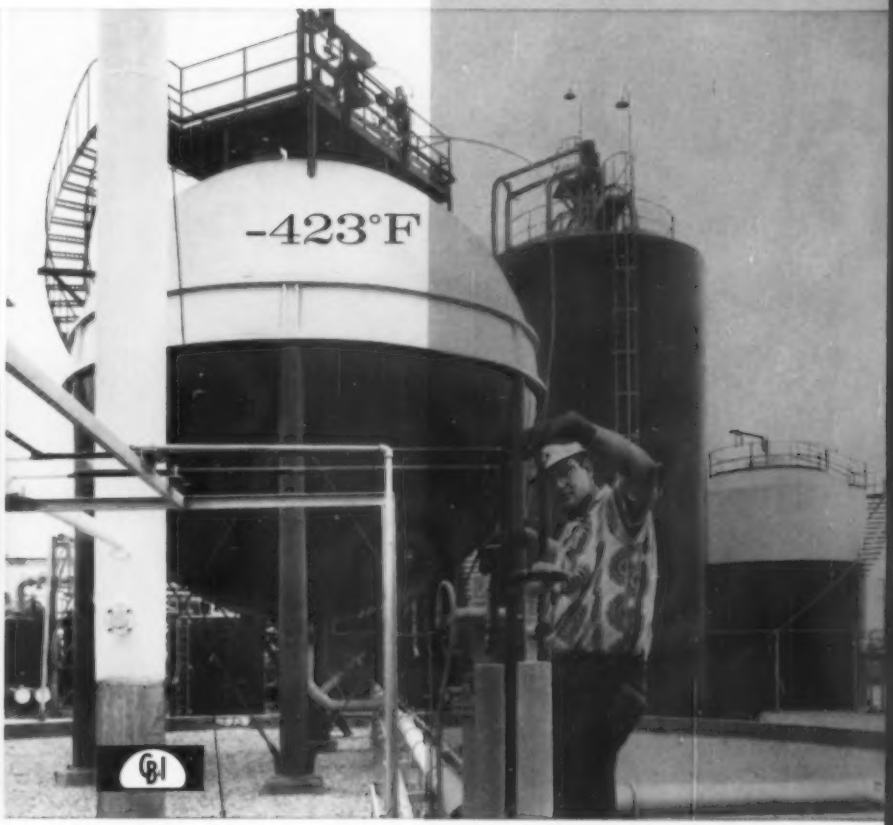

These double-wall cryogenic storage tanks play a vital role in the first privately-owned plant to supply liquid hydrogen on a large-scale commercial basis. Hydrogen is stored in the sphere at −423°F and nitrogen in the cylindrical tank at −320°F. Located in Torrance, Calif. and owned by Linde Company, Division of Union Carbide Corporation, the plant will deliver 3,300,000 lbs. of liquid hydrogen yearly to missile centers. Both tanks were designed (using Linde-approved designs), fabricated and erected by CB&I, world's most experienced builder of cryogenic vessels.

ABOVE: Aluminum inner shells and carbon steel outer shells were used for the two cryogenic tanks. The spherical tank is 28 ft. in diameter and the cylindrical tank 21½ ft. Special insulation is between the shells.

TOP LEFT: The inner sphere is suspended in the outer sphere by stainless steel rods positioned around the perimeter. Resting on the ground nearby is the aluminum inner shell of the cylindrical nitrogen tank.

LEFT: A trailer is being loaded with liquid hydrogen for delivery to missile centers, other government installations, or industry.

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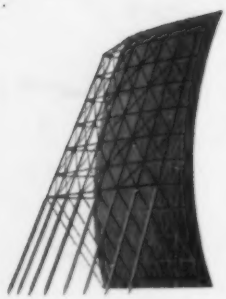
A decisive move was made late in 1960: the first BMEWS (Ballistic Missile Early Warning System) radar station began operating at Thule, Greenland. This system keeps a 24-hour vigil against aggression by enemy ICBM's. Huge klystrons produced by Varian are the heart of the BMEWS transmitter sub-system. The powerful tubes generate radar signals—sent from antennas big as football fields—to seek out possible airborne intruders.



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